October/November 1987

AIR & SPACE

Smithsonian

Space toys
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The revolutionary aircraft Voyager.

Voyager, Rolex, and one of the last great challenges of long-distance flight.

They called it quixotic. Impossible. It had never been done. Not even dared.

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But Dick Rutan and Jeana Yeager dreamed it. And did it. On a mid-December morning, they took off into history. Nine days later, they landed in the record books.

It hadn't been easy. Not even for seasoned pilots who make a routine of record-breaking. Rutan, a retired Air Force lieutenant colonel, and Yeager, a drafting engineer, already held numerous world-distance and closed-circuit titles.

Record-breaking pilots Jeana Yeager and Dick Rutan.

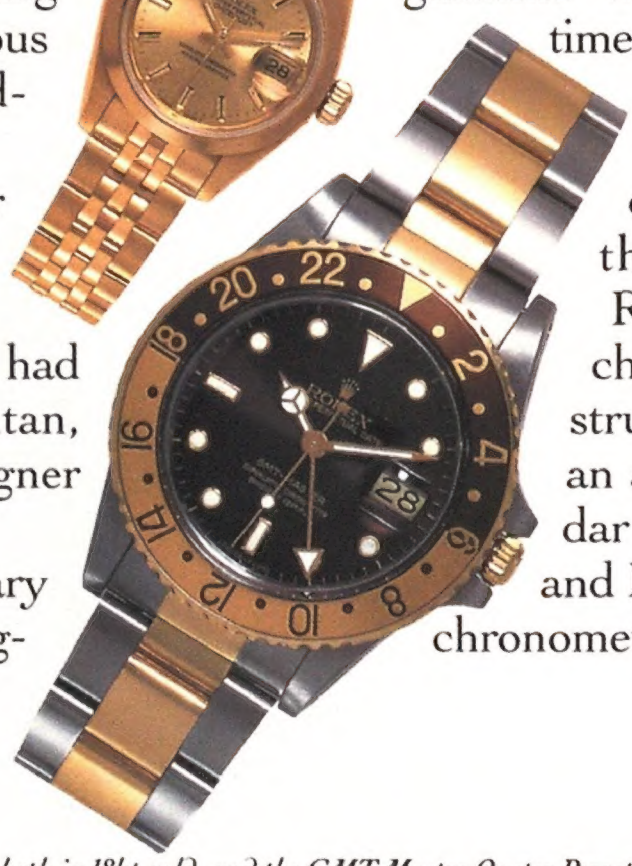
Yet much more than their exceptional personal skills was required to capture this laurel. A radically new plane had to be created by Burt Rutan, Dick's renowned aircraft-designer brother.

Voyager, the revolutionary craft he conceived, has a wing-

Voyager's irregular flight path, chosen to vector it around strong winds.

span longer than a 727's and can carry as much fuel as a tank truck. Yet it's lighter than a small automobile. At takeoff, the gasoline weighed almost four times as much as the 2200-pound plane itself.

Because of the critical need to keep their aircraft light, Rutan and Yeager chose a minimum of instruments. Among them, an automatic pilot, a radar weather unit, and Rolex chronometers.



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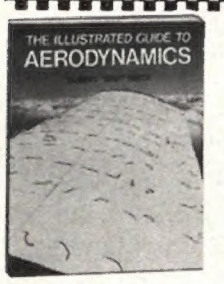

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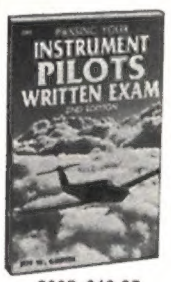

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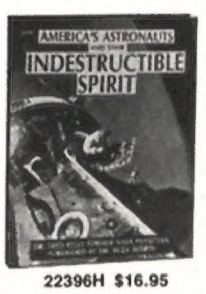

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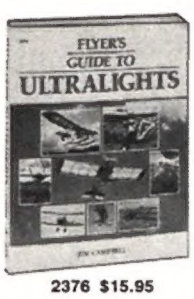

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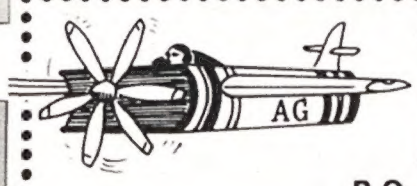

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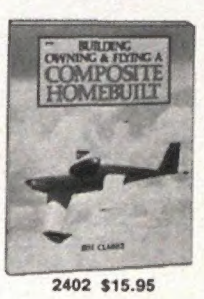

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October/November 1987 Volume 2, Number 4

AIR&SPACE
Smithsonian

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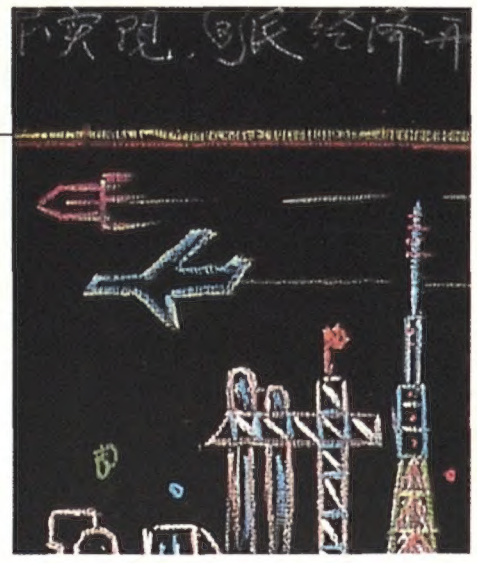

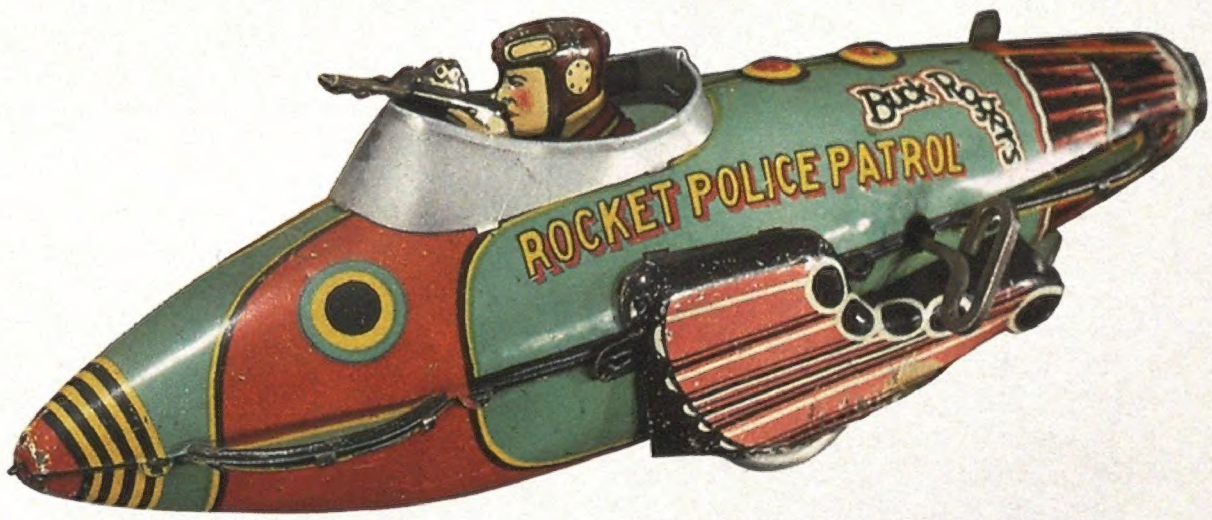

AIR & SPACE/Smithsonian (ISSN 0886-2257) is published bi-monthly by the Smithsonian Institution, 900 Jefferson Drive, Washington, D.C. 20560. Subscription price $18 a year in U.S. possessions, $24 elsewhere. 85 percent of dues is designated for magazine subscription. Single copy price, $3.50. Second-class postage paid at Washington, D.C. and additional entry points. Editorial offices at National Air and Space Museum, Washington, D.C., 20560. Advertising and circulation offices at 420 Lexington Ave., New York, NY 10170. Members: Please address all subscription correspondence and change of address information to P.O. Box 53261, Boulder, CO 80322-3261. Postmaster: Send address changes to AIR & SPACE/Smithsonian, P.O. Box 53261, Boulder, CO 80301-3261.

Photographic Negative

Eighteen years ago last July, Neil Armstrong and Edwin (Buzz) Aldrin touched down on the moon. One of the most famous photographs ever taken was that of one astronaut, faceless behind his mirrored visor, standing firmly on the forbidding lunar surface. That photograph made the cover of *Life* magazine and practically every other news publication in the world, burning itself into our collective consciousness. Most people are sure the photograph is of Neil Armstrong, the first man to set foot on the moon.

They're wrong. All the famous Apollo 11 shots show Aldrin, not Armstrong.

Recently, two researchers from Great Britain, hoping to establish whether even one good Armstrong photograph exists, turned to the National Air and Space Museum. They wondered whether, between the Museum's vast collections of space photography and the recollections of its staff, an image could be found. Incredibly, the answer may be no.

Armstrong, although assured of his rightful place in history, seems to have gone unrecorded—photographically at least—through sheer mischance. A chagrined National Aeronautics and Space Administration discovered the lapse the night the astronauts returned to Earth. NASA officals combed frantically through the freshly developed negatives, transparencies, and movie film looking for even one high-quality image that was certifiably of Armstrong. The search dragged on for hours while hundreds of reporters waited. Finally, a luckless public affairs officer had to wake Armstrong to ask: "Neil, when did you hand the camera to Buzz?" Armstrong's answer: "I never did." NASA had to settle for releasing the now-famous picture of Aldrin—noting that it showed Armstrong reflected in the faceplate of Aldrin's helmet.

How could NASA, with its keen public relations sense, have allowed the astronauts to miss the most obvious picture on the biggest mission of all? Why was the fact that there was no instruction for Armstrong to hand the single Hasselblad still camera to Aldrin not caught in pre-mission planning? Did Mission Control ever realize that Armstrong was taking all the pictures? Those are the questions the British historians, H.J.P. Arnold of England and Keith T. Wilson of Scotland, have been asking the National Air and Space Museum.

Today Armstrong insists there is a clear view of him "in the background" of one photograph. Arnold, who has devoted years to poring over every frame of Apollo photography, believes that Armstrong is mistaken. NASA's photographic expert, Richard Underwood, is also convinced there is no still photograph of the first moonwalking astronaut, although Armstrong does appear alongside Aldrin in some fuzzy 16-mm movie footage taken by an automatic camera.

Certainly, it's a shame to have no good photographic record of one of history's most famous explorers at his moment of triumph, but the oversight did have one useful result. NASA discovered that it is impossible to tell who is who inside a spacesuit without help. The immediate solution was to sew a red stripe around the upper legs and arms of one suit for missions in which two astronauts went outside a spacecraft together. The stripes didn't appear on the suits until the Apollo 13 mission, so visitors won't see them in the Museum's lunar landing display. They do show plainly in Bob McCall's famous spaceflight mural near the Museum's entrance and in the spacewalk scenes in the IMAX film *The Dream Is Alive.*

What will NASA do when it has to keep track of more than just two spacewalkers? Will astronauts blossom out in red, blue, and green stripes? Or will we see numerals and names on the backs of the suits, like football players' uniforms? It's a problem NASA will have to solve. As the mission control experts, journalists, and, eventually, historians have learned over the past 18 years, you can't tell the spacewalkers without a scorecard.

—Brian Duff is the Museum's assistant for special projects. In 1969 he was director of public affairs at NASA's Manned Spacecraft Center in Houston.

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THE SPACE STATION: WHAT WILL IT DO FOR US ON EARTH?

For more than three decades mankind has explored the mysteries of the universe from a vantage point in space. Now we're turning space into a practical place to work.

By the mid-1990s NASA's Space Station is scheduled to give science a permanent platform in orbit. A place where researchers can examine our world from a unique perspective and experiment under conditions of extreme temperature and weightlessness.

In zero gravity, compounds can react in ways not possible here on Earth. Scientists can create better medicines, more-durable plastics, and stronger alloys made of metals that resist mixing under gravity's pull. The Space Station also will give astronomers a manned observatory for long-term studies of the universe, while Earth scientists will gain a facility from which to better understand our planet.

There are currently six major work packages in the Space Station's development. Lockheed is a key member of each. These packages are to become the foundation of a permanent presence in orbit that promises dramatic advances in our understanding of space and its usefulness to people on Earth. Drawing on decades of experience in countless areas of space science and technology, Lockheed is helping give mankind an invaluable tool with which to master this new frontier.

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Letters

Law, Science Fiction, and Reality

The establishment of the First Principles of the Governance of Space Societies ("Law of the Next Frontier," August/September 1987) is a unique accomplishment but not a unique idea. Science fiction writers have been experimenting with "space laws" for decades. Like many ideas these writers have developed, a reality has emerged. If one reads writers such as Heinlein, Asimov, and Clarke, a treasure trove of ideas for the Space Age will be uncovered.
Karen Balter
New York, New York

Whistler's Brother

As an engineer, I find it difficult to believe "Whistler's Brother" by Stephan Wilkinson (Soundings, August/September 1987).

The range capability of an automobile speed-radar receiver is laughable compared to that needed for defensive purposes; response time is a factor. Secondly, to attach an electronic system with Velcro in a fighter aircraft is beyond conception—aerodynamic forces and vibrations at high velocities must be accounted for. Finally, suggesting that military specifications were largely ignored (other than stenciling) is making a mockery (undeservedly so) of the military.
Lisa Maenza
Middle Village, New York

Stephan Wilkinson replies: What is *laughable is the power of a police radar transmitter. Give a good radar detector a tremendously powerful and highly focused radar beam to detect, as opposed to one of those hand-held microwave transmitters that cops aim, and you'll see range on the order of tens of miles.*

That MilSpecs were not followed is quite true, though it isn't so much that they were ignored as that the Navy could not force Whistler to adhere to them. The Navy was entirely welcome to demand MilSpec adherence, and Whistler was entirely welcome to say, "Fine, go buy your radar detectors from somebody else." That's exactly what happened.

You're right about Velcro holding the radar detector in the cockpit: nobody would mount a semi-permanent device that way. An error in editing obscured this. What should have been said is that the first guy to try it—the test pilot who supposedly put one in his F4—did it with Velcro.

Bridge for Sale . . .

If I could just have the names and addresses of those people who have bought tickets for a ride into orbit ("The World on $52,200 a Day," August/September 1987), I have a lovely old bridge in New York that I would like to sell a piece of. I'm quite sure that I would have 246 willing investors.
Samuel Starr
Rose Valley, Pennsylvania

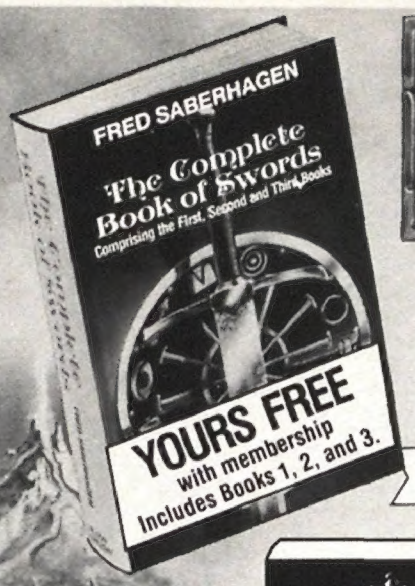
Where the Value Is

I have a little trouble with the Sänger "space plane" concept ("The High-Flying Legacy of Eugen Sänger," August/September 1987), based on memories of a study of his "antipodal bomber" proposal—known ever since as "The Sänger-Bredt Report"—and of related projects that I did in 1946 when I was an engineer on General Electric's Project Hermes.

Sänger calculated the performance of his bomber by using the classic Breguet equation for range. To do that, he needed lift/drag ratio data for up to about Mach 30. The only supersonic data available to him would have come from tests in the blow-down wind tunnels at Peenemünde, and would have been limited to a maximum of approximately Mach 4.3.

The predicted performance of the A4 V12/c was overestimated by about 100 percent. I believe that the intercontinental performance predicted by Sänger never could have been achieved.

There was real value gained from Sänger's work, though. Because of the proposed rail-launching scheme for the



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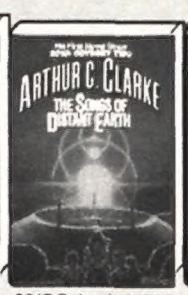

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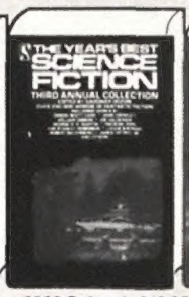

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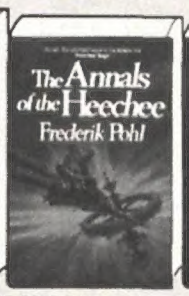

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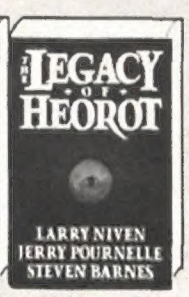

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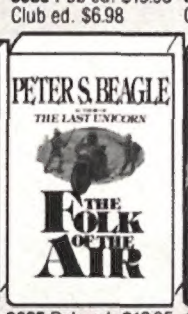

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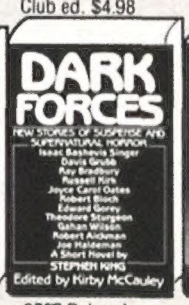

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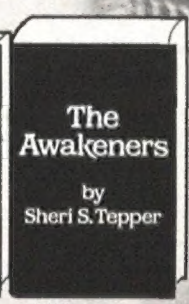

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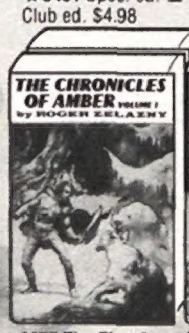

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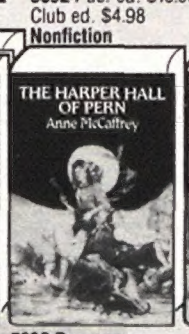

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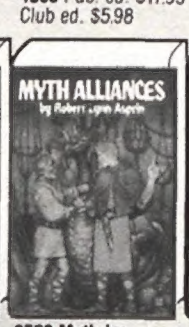

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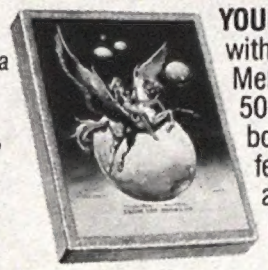

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bomber, he initiated the earliest tests of high-speed friction generated by metal on metal rails. I believe these data were found useful later in the development of the high-speed tracks widely used in this country to test ejection systems, among other devices. He also made valuable calculations of the evaporation rates of contained quantities of liquid oxygen, the oxidizer for the bomber's rocket engine.
David A. Anderton
Ridgewood, New Jersey

Editor's reply: As the article states, Sänger knew that his antipodal bomber would have required five to eight years of testing and refining. In his 1944 proposal, Sänger outlined 12 stages of development, including rocket sled tests that would subject the airframe to speeds "so that the Mach number [would be] duplicated exactly." But the project was canceled in its first stages of development. Of course, Sänger's revival of a winged aerospace plane was based on 15 more years of work after the war.

Right Bus, Wrong Town

Reading "Bus Stop" (In the Museum, June/July 1987) leads one to believe that the Jet Propulsion Laboratory is manufacturing the *Magellan* spacecraft. Actually this spacecraft is being manufactured, integrated, and tested by Martin Marietta's Denver Aerospace Division.
Michael A. Jacobs
Aurora, Colorado

Editor's reply: You're right. JPL, which is managing the Magellan project, has named Martin Marietta-Denver Aerospace to build the spacecraft. The JPL crew that removed the Voyager bus from the Museum's display shipped it to Martin Marietta in Denver, not to JPL in California, for testing.

From A to E

J.E. Ferrell, not J.E. Farrell, was the author of "Role Model," the cover story for the June/July 1987 issue. *Air & Space/Smithsonian* regrets the error.

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In the Company of Condors

I asked all the pilots I met. With only three legs left of my flight over the Andes—a stormy, spectacular journey that had begun two weeks ago in Chino, California, and that was to end a few days hence in Asuncíon, Paraguay—I was desperate for news of condors. The real purpose of my trip was to deliver a Sperber RF5B motor glider, a two-seater equipped with a turbocharged Volkswagen automobile engine, to its new owners. At the time I embarked on this mission, the spring of 1980, I had already soared several times in the company of giants—the very rare California condors, whose grace in flight can be appreciated best from the air. I hoped that on my trip to Paraguay, which would take me through Mexico, Central America, Colombia, Ecuador, Peru, and Bolivia, I would have the chance to observe Andean condors in their natural element—the skies over the Andes Mountains.

In Talara, the entry port for Peru, I had trouble convincing the Peruvian air force security officers who formed my reception committee that the cameras mounted on the Sperber's wings and tail were intended to photograph condors, not military installations. They confiscated my cameras and film and ordered me to follow their old Antonov turboprop to Lima. During the six-and-a-half-hour flight, I nervously watched the fog from the cold Humbolt current gradually move in under me. When I arrived at Lima's Jorge Chavez Airport in dense haze at sunset, I was greeted by a small fleet of jeeps and air police.

Jack Lambie

In 1980 the author braved cloud-filled canyons to soar with condors.

The air force insisted I be their guest in a private room surrounded by machine gunners. The next day, after convincing the uptown Lima security people that I was a bird expert interested only in the condor, I got my cameras back—with ruined film and minus 14 rolls that had recorded the dramatic leg from Panama to Colombia.

Now free to continue my journey, I started asking around Lima for the best route to follow in search of condors. Two old pilots said they had spotted one 20 years ago while flying up the coast from Tacna in a Piper Cub. Bolivian glider pilots who'd been soaring in the Andes for 30 years said they'd never seen a condor. I decided to fly farther south along the coast before turning inland toward Paraguay. I kept hoping.

Back at Chavez Airport, the Sperber passed my preflight inspection. Throttle open, the motor glider gained speed until I could ease it into the air. I retracted the single main wheel and glanced at the airspeed indicator. Zero. In their final search, the air force police had inadvertently disconnected the internal line to the airspeed gauge. But another gauge reported that the engine was hauling us upward at 500 feet per minute, even with 240 pounds of fuel.

Off the end of the runway, bits of fog hovered in the hazy sun. I flashed quickly through the first patches, then into a thick fog bank. The Sperber was equipped with instrument-flying gauges, but the turn-and-bank indicator wasn't working. I kept the glow of the morning sun on the left side of the cockpit and climbed.

My heart was pumping—I knew from my charts that the ground rose around Lima. The sun began playing tricks: its glow, reflected off the tops of the clouds, leaped to the right, then ahead. I was tempted to try to follow the sunlight into clear air, but if I chased the shifting, glowing spot as it bounced around the clouds, I could easily become disoriented and drop into a spiral dive. Minutes later, I pulled clear.

Fifty miles south of Lima the fog below me thinned and I could see the coastline of Peru. I slowed the engine and glided to the Islas de Chincha and Las Balestas, refuges for birds and sea mammals. Condors feed on dead sea lions and bird eggs. I hoped I might find them roosting here.

Thousands of seabirds surged over the mesa of the first tiny island. Small beaches among the scalloped cliffs were crowded with sea lions, which looked like giant slugs. But there were no condors. Las Balestas

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With a wingspread of 10 feet, the Andean condor is the world's largest flying bird.

was sparsely birded and bare, so I skimmed over the sea to Isla de Sangayan, where a few seabirds calmly circled.

On to the Peninsula Paracas, where the narrow beach and the 300-foot wall above it filled me with a sense of déjà vu: for a long moment, I was back home at the Torrey Pines Soaring Contest near San Diego, California.

In the midst of my reverie, I saw something that looked like a hang glider dive from the cliff and glide past me. I banked in time to see a flash of white ruff on the neck of the creature as it slipped over the edge of the escarpment into a sandy bowl. It was like coming face to face with a celebrity I'd watched on TV for years.

The size and weight of these birds keep them from flying very long without help from up-currents. After 30 seconds the condor landed in a spray of sand on the side of a hill. I maneuvered to position the wingtip camera for a picture of this giant, but in the 45 seconds it took me to come back around, the bird took off, skimmed over the edge of the cliff, and disappeared.

I had glided barely 15 miles south when the scene was repeated. This condor leaped from the cliff, pulled up over the edge, and was gone.

For almost 30 minutes, mine was the only pair of wings in the sky. Then a shadow crossed my canopy. Four immense condors were circling above me. I pushed on the left rudder pedal and eased the stick left to stay under the birds. Three were young with dark brown plumage. I decided to pursue the adult with its striking black and white feathers, and rose toward it on the thermal. Each time I flew close it would fold its wings, roll, and dive.

Unlike the fearless California condors, which had merely ignored me and my motor glider when I soared with them several years ago, the Andean condors wanted nothing to do with me. Photographing them from the cockpit while trying to fly the glider in a chase pattern was rigorous, frenzied exercise. I'd position the glider for a turn, pick up the camera, lose the condor, reposition the glider, reach for the camera, feel the glider shudder, grab the stick, and drop the camera. With no airspeed indicator, I had to rely on the feel of the aircraft to avoid a stall. I listened to the air rushing past and kept alert for the warning shudder.

The bird dove into a gulley. I stayed above and watched this clever flier skim out to the beach and disappear. I was exhausted from the chase. Sweating and trembling, I decided not to pursue him.

I turned inland, toward the Peruvian desert. Never have I passed over such eerie stretches of sand, rock, and snaking canyons. A shimmering sea haze made visibility poor in this empty, lonely world, but by skimming the ground, I could see a riverbed with irrigated fields ahead. Beyond, strange lines were traced over a stony, bluish desert. Among the faint markings, I made out images of a huge monkey and a condor. These were the famous Nazca markings, viewed since prehistory from the vantage of the surrounding hills.

I moved into the rumpled foothills of the mountains, where the strong lift made flying rough. The bumps became so violent they interfered with the fuel flow, and the engine coughed intermittently.

I soared to 13,000 feet and flew farther into the rows of higher mountains. Just as I climbed over a narrow ridge, I saw a pair of huge wings: an old male condor with red wattles on his head and neck eyed me calmly, rolled and dropped past me, then sped down the canyon.

Lake Parinacocha drifted by under my wing. I passed the 22,000-foot Nevada Sara Sara, then the incredible canyon of the Rio Ocana. People who suffer from a fear of heights are usually unafraid to look down from an airplane window; the landscape below seems merely small, not distant. But a reference point, such as a mountaintop, can make you uncomfortably aware of the distance to the bottom of a canyon. High above the Rio Ocana, I was seized with a frightening sense of height. I pulled the motor glider in close to the edge of the canyon, searching for lift, and rode up on a thermal.

A strange pattern in the rocks appeared. Walls, foundations, and streets clung to the mountain. I realized that I was flying across one of the many unexplored prehistoric sites in South America.

A dot moving between peaks grew into the big, flat, airplane-like wing of a condor. I lost sight of it from time to time but finally closed in by following its shadow as it leaped along the rocks. Once I got close enough to almost touch the bird, but it twisted and turned, following a wall of rocks in the narrow canyon. I was forced to circle up and out.

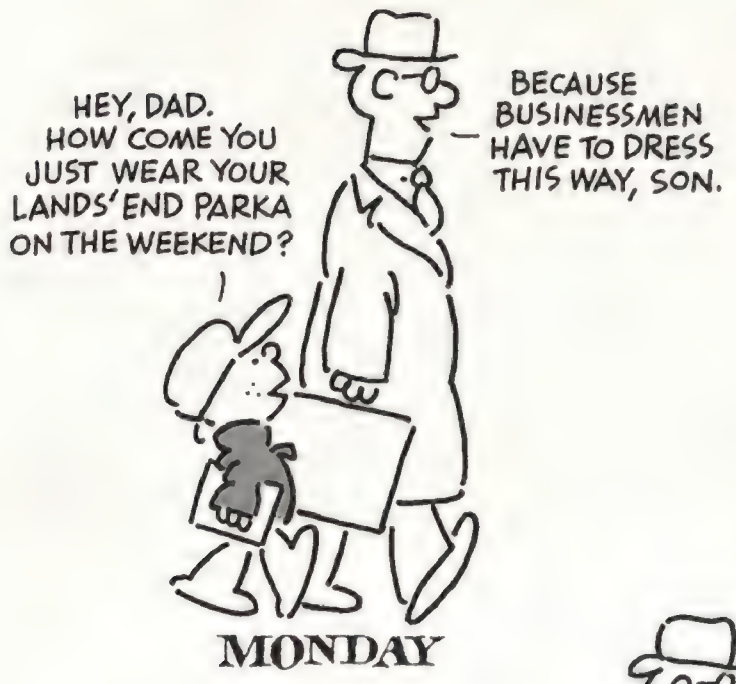
On my tape deck, a Bach prelude, well suited to mountain flying, had drifted into the background. Turning up the volume had no effect: I'd been flying at nearly 17,000 feet for the last few hours, and I dimly reasoned that the thin air had affected my hearing. I put on the oxygen mask. Two deep breaths brought back my hearing and Bach boomed in the headphones again.

The big Sperber was now floating over a more gentle landscape, with peaks reaching only to 14,000 feet. I glided over plateaus, chasms, and rolling brown fields. Some of them I remembered from Skylab photographs I had studied in preparation for the trip. But just as the living condors had been more wondrous than their photographs, so this magical landscape sparkling in the clear air of the Andes looked more beautiful than it had appeared on film. The ponds and small lakes of meltwater were calm, and cloud shadows stood still. The ground was so high that visibility didn't fade gradually as it does in the hazy air of lower elevations. A railroad track cutting cleanly through the brown grassy slopes was sharp-edged and seemed disorientingly near.

I saw a strip of blue on the horizon and realized that I was approaching the famous Lake Titicaca. In another hour, the great lake was spread slate-smooth before the glider, and I could see on the surrounding plain a few dirt roads and some Indian huts.

I flew on until the ground was in shadow. Chilled, I pulled a towel around my shoulders as I glided over Lake Titicaca's giant blackboard of water at the border of Peru and Bolivia. Despite the cold and the darkening cockpit, I was warmed by the knowledge that friends were near. I had written the Ayar Uchu Glider Club in La Paz about my trip many weeks before. In just minutes I would be joining them and trying to convey the thrill of soaring with the graceful companions I had encountered over the Andes.

—Jack Lambie



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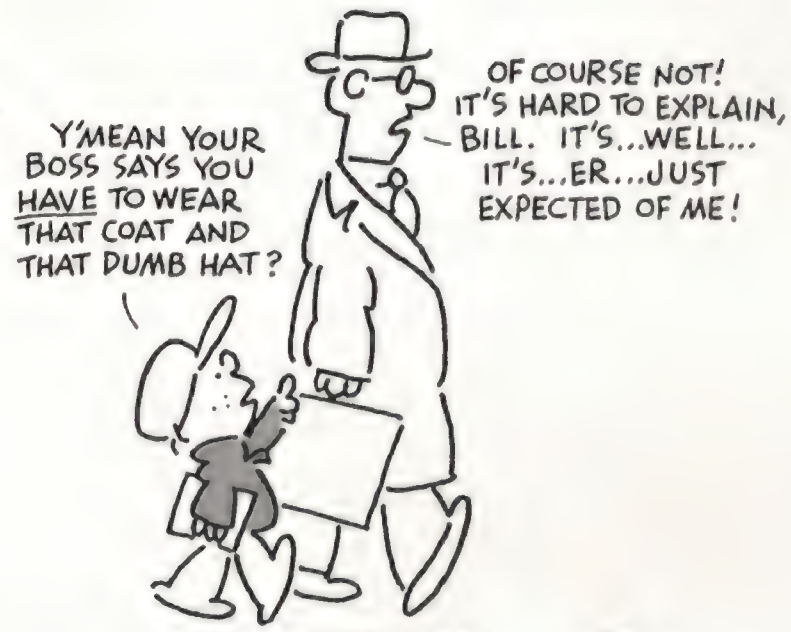

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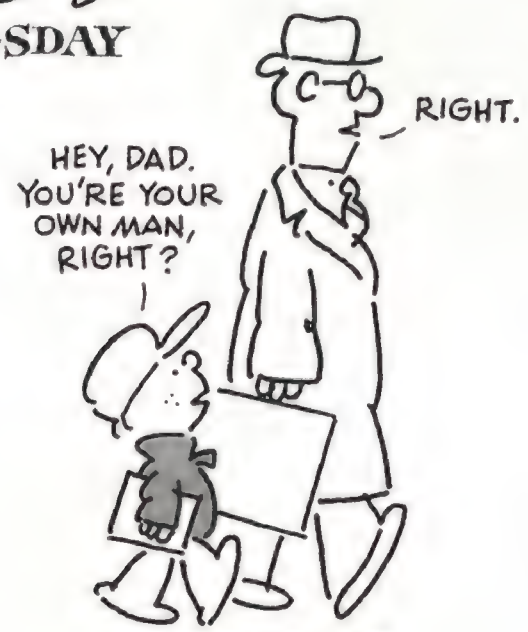

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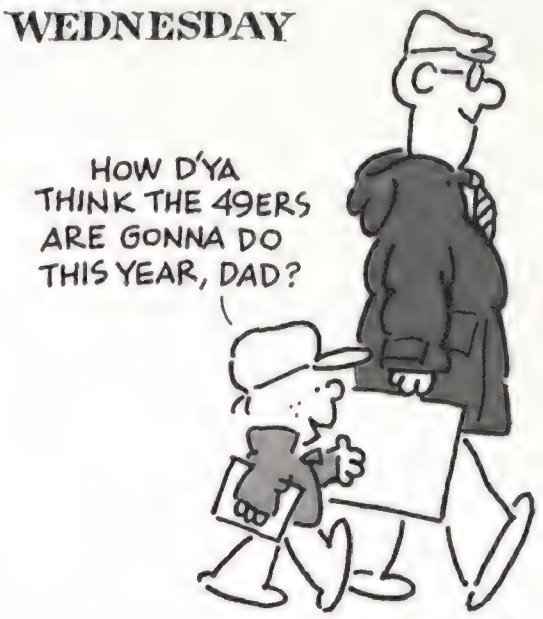

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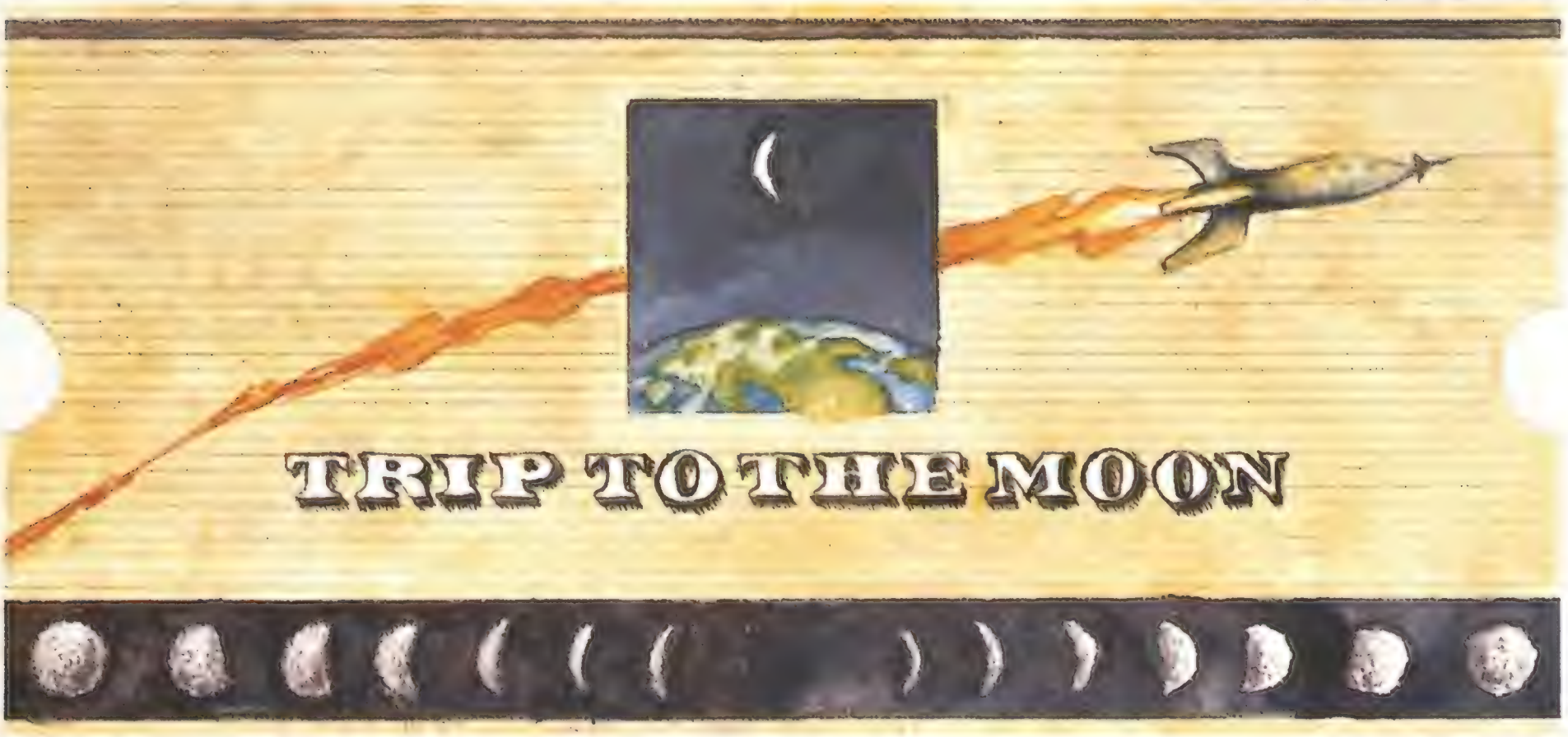

At age 11, Carl Phillips earned a trip to the moon—or so he thought. In 1958, Phillips, now 40, was one of 10 winners in a Louisville, Kentucky radio station promotion that required contestants to write an essay on "Why I Want to Go to the Moon." The prize was an all-expenses-paid lunar flight, scheduled to depart on March 15, 1987.

Earlier this year Phillips contacted the station, seeking to collect his prize. "I called him back," says WAKY general manager Jack Hogan, "and said, 'Well, there is no spaceflight, we don't know anything about it.' In fact, several other winners called us. I think they were just anxious to see our reaction, and we're in a quandary about what to do. This station has probably gone through five ownership changes since 1958, so the legality of the contest would go back to whoever owned it then. We were surprised that people had kept their tickets all that time."

Actually, Phillips hadn't. "I hung on to it for years, but it finally went through the wash one too many times," he says. He does remember showing it off in a bar the day Armstrong and Aldrin walked on the moon. "It was a yellowish orange thing about the size of a driver's license and it said 'Bearer: Trip to the Moon.' It didn't say it was a *round* trip, though." Anyway, Phillips can now admit he didn't even write his entry: "There was a girl living across the street who had a crush on me—we were in the sixth grade—and she wrote it, signed my name, and sent it in."

He later developed an appreciation for the topic. "I was really into aeronautics in college," says Phillips. "I even waxed Learjets. Now I'm in real estate and imported cars, but I'm still a fun-loving guy—I'm kind of into everything. So I really want to go to the moon. I'm willing to wait a little longer."

WAKY program director Mark Strauss isn't advising winners to stand by for their flights, but he does suggest that they hang on to their tickets. "They're great souvenirs of the early days of rock 'n' roll radio."

—*Michael Rozek*

The Turbofan of My Aunt Is in the Nacelle by the Fuselage

Gudmundur Hardarson has his private pilot's license and more than 100 hours in Piper Tri-Pacers and "the Cessna One Seven Two" back home in Ísafjördur, Iceland. He wants to move up in aviation, but he has not come to Prescott, Arizona, to fly. He is at Embry-Riddle Aeronautical University, along with 19 others from 10 nations, to learn English—specifically, aviation English.

English is the medium of exchange for international flights, and an exacting comprehension is vital. One must understand, for example, the difference between holding *at* the runway or *on* the runway. Hardarson speaks a careful Nordic kind of English that gives the illusion of fluency, but he cannot, for example, penetrate the vernacular involved in a joke about how another One Seven Two beat him into Red Square.

"English for Aviation" is taught by ELS Language Center instructors on Embry-Riddle's Prescott campus, which is modeled after the air force academy of some small but very air-minded nation. After completing the four-week course, which costs $1,040, many students go on to enroll at Embry-Riddle to pursue careers in aviation management, engineering, maintenance, computer science, avionics, and flight technology.

Students are divided into two groups based on their aviation experience and knowledge of English. Hardarson, for example, is in the advanced aviation group and the intermediate English group. Each class spends three hours a day on general English and three hours on aviation English. Twice a week, Embry-Riddle faculty members lecture on meteorology, aerodynamics, turbine engines, maintenance, and airline operations and management.

This year's English teachers are Veronica McCormack and Marie Cloutier, both of whom fly. Teaching English as a second language requires equal amounts of empathy, affection, and language skills. McCormack and Cloutier seem to reach in and extract the latent English within each student. And because living in a country without speaking its language turns everyone into children, there is a familial air to the classes.

This morning McCormack uses a sketch of a Piper Cherokee 140 to explain the major components of an airplane to the intermediate aviation group. One by one, the students come to the VuGraph to write in *propeller, landing gear,* and *power plant.* Hameed Muthana, a crew dispatcher from North Yemen, adds *rudder.* McCormack asks for its pronunciation. Rooder? No, RUHder. How many wings? How are they differentiated? Someone adds *empennage* to the drawing, to applause. What's another word for *fuselage?* "BODY!" comes the chorus.

Meanwhile, the intermediate English group is working on *may, can, might, may be,* and *maybe.* Sample sentences fly until Celio Gonzalez, a private pilot aspiring to a position with Spain's Iberia Airlines, goes off on a tangent: "Get *off* the plane?" How, if one is not *on* it but *in* it? "Well," Cloutier admits, "we just say we are *on* the plane, so then we say we get *off* it." And no, she adds, it is not like *takeoff.*

More sentences travel the circle of students. It is Taha Hassan's turn to deal with the test question, "What is your new son going to be when he grows up?" Hassan does not hesitate. "He *might* be a pilot." And he might come to Prescott.

—Carl A. Posey

On the Ban Wagon

This year marks the 50th birthday of Bausch & Lomb's Ray-Bans, the classic sunglasses that have become an aviation—and, lately, a fashion—requirement. Ultra-cool, they seem to possess an appeal as timeless as their styling.

Ray-Bans are direct descendants of the dark goggles developed by Bausch & Lomb at the request of the U.S. Army Air Corps in the late 1920s. Air corps pilots swore by

NASM

the glare-reducing lenses, so in 1936 Bausch & Lomb went public with them under the name Anti-Glare. Despite a $3.75 price in a market flooded with 25-cent models, Anti-Glares were an immediate hit.

The following year Bausch & Lomb adopted the name Ray-Ban for its new product line and simultaneously unveiled a model that later became known as Aviators. Because they offered lightweight frames, as well as excellent optical quality—critical when scanning for enemy aircraft—the U.S. Army and Navy procured Ray-Bans for their pilots. Aviator glasses were by no means confined to the cockpit, however: they went everywhere U.S. servicemen fought glare on land and sea. General Douglas MacArthur, who wore his to war in 1942, is one of the most famous Ray-Ban customers of all time. Today, his Aviators—along with his hat, pipe, and five-star insignia—are on display in the MacArthur Memorial in Norfolk, Virginia.

Ray-Bans are no longer standard issue in the services, but they have been *de rigueur* for rising Hollywood stars ever since Tom Cruise sported the flat-fronted 1950s-style Wayfarers in the 1983 comedy *Risky Business.* In 1985, Bausch & Lomb won a Council of Fashion Designers award for Ray-Bans' "increased presence in contemporary fashion," and when Cruise donned Aviators in last year's hit movie *Top Gun,* sales soared to new heights. Today Aviators come in 100 versions, including a $139 gold-plated model called "The General" and a pair with 14-carat-gold frames, the price of which fluctuates with that of gold.

With black ink and good press overflowing, Ray-Ban now sponsors a designer flight team. The Ray-Ban Golds Aerobatic Team, four Canadian airline pilots flying Pitts S-2As, performs at 30 airshows each year. Is it safe to assume they wear their sponsor's product? "If they don't," says Norman Salik, vice president of marketing, "I'll shoot 'em down."

—Jay P. Spenser

The Neat Stuff in Space

Comprehending the universe is a challenge. Trying to explain it to a child is nearly impossible. Yet *Odyssey* does it every month.

Odyssey, "The Young People's Magazine of Astronomy and Outer Space," is directed at 8- to 14-year-olds. "We have quite a few adult readers, too," says editor Nancy Mack, "but they don't like to admit it." Mack says the tricky part of her job is "trying to make what is often a very technical subject interesting and understandable."

By all indications, *Odyssey* succeeds. Founded in 1979 as a sister publication of *Astronomy,* the magazine has nearly 100,000 young subscribers, addressed as Cadets. Features on astronomy and aerospace are accompanied by pronunciation guides ("jee-oh-SIN-kroh-nuss"), and many have instructions on building a model of the topic: a recent issue contained cutouts for the Earth-moon and Pluto-Charon double-planet systems. And in an era of TV-induced passivity, *Odyssey* urges its readers to get out and "make friends with the stars," using the Starry Sky Map in each issue.

Odyssey also runs an opinion poll every month. One asked children where in the

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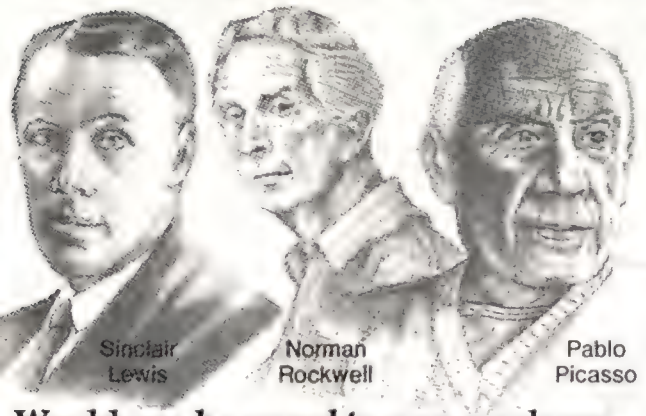

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Odyssey

solar system they would most like to travel (Pluto won), and another, posed after the loss of *Challenger,* asked if any of them would like to be the first student to fly in a shuttle. Two-thirds said yes, but one reader wrote, "No, I'd just get in the way. Besides, I have better things to do, like keeping my feet where they belong." Another agreed, writing, "I wouldn't go. I don't trust NASA any more."

"Many of them were very shook up over the accident," Mack says. "The shuttle was *their* space vehicle—they are too young to remember Apollo." But children are more concerned about the delay in space exploration, according to associate editor Greg Walz-Chojnacki. "They want to pick up the pieces and get going again." *Odyssey* doesn't sugar-coat space to make it digestible. It ran a feature on why *Challenger* exploded, and did a story last February on the decline of the U.S. space program. "For the past 10 years," it said, "America has been sliding toward second-class status in space."

Odyssey

Kids contribute poems, puzzles, and artwork, and also send in questions for a robot named Ulysses. "What's a light year?" is typical, but others are more personal. "My mom won't let me go outside to go observing," a reader wrote. "What should I do?" Ulysses' solution: "Ask Mom to go observing with you!"

"Ulysses is very popular," Mack says. "He's modeled on the average 10-year-old: about four feet tall and a lot smarter than anyone thinks." Children visiting the editorial offices in Milwaukee inevitably want to meet the robot. Says Mack, "We tell them that he's either at a birthday party or in for a lube job."

—Ken Croswell

Crockett, Tubbs, and Harold

Fernandez knew he had him. The FLIR Systems Model 2000 infrared unit detected the suspect hiding near the stove in the darkened room. For a moment, he wished he had his gun—but the danger seemed past. He moved in to collar his quarry.

"I hate him," Joe Fernandez sighed. "I hate all hamsters."

Fernandez, an aviation management consultant in Loomis, California, has three young sons, a hamster named Harold, and a garage full of aviation gear. One evening, when Harold broke out of his cage for the umpteenth time, Fernandez tore the house apart looking for the boys' favorite pet. No luck. "But I did find a lot of lost toys," he says.

Then he remembered the infrared unit sitting in the garage. The FLIR—Forward Looking Infrared—is a surveillance tool used by utility company, military, and law enforcement helicopter pilots to discern heat-emitting objects, such as bad power line insulators, lost children, and suspected criminals. The 50-pound unit is mounted on the outside of the helicopter and viewed and controlled from the cockpit.

Carolyn McIntyre

"I whipped that baby out and started a room-by-room search," Fernandez says. After about an hour, the FLIR picked up a glow from a metal fire box on an antique stove. "Usually, the only thing on a hamster that glows—besides his butt, after I kicked it—are his eyes," Fernandez gloats. "Apparently Harold didn't know that a shiny metal surface will reflect and sometimes intensify infrared radiation. The kids put him in protective custody. That's the way it went down." Fernandez says now he has to figure out how to stencil a hamster on the FLIR 2000.

—Patricia Trenner

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Bob Harris

Riding the Wave

Pilots who soar in graceful, long-winged sailplanes rhapsodize over their sport, comparing it to the flight of birds. Bob Harris, an industrial hardware salesman from Riverside, California, used to feel that way too. But after breaking the 25-year-old glider altitude record with a climb to 49,000 feet last year, he's not sure if he'll ever soar again.

What soured Harris on soaring was the very thing that enabled his ascent: a spiralling column of air known as the Wave, which draws glider pilots to California's Sierra Nevada range just as the waves of Waimea Bay draw surfers to Oahu.

A mountain wave, or rotor, occurs when a large air mass collides with a mountain range, flows over the peaks and into the valleys, and bounces up with tremendous force. Harris says that at altitudes above 9,500 feet, the wave is as tranquil as the eye of a hurricane. But as an aircraft negotiates the roiling currents and strong down-drafts at the base of the wave, it takes a terrific beating. In fact, Harris wasn't sure that the wings of his sailplane would withstand the turbulence encountered in the atmospheric Cuisinart during the practice runs he made prior to breaking the 46,267-foot record.

Harris began his quest at Owens Dry Lake in 1981. "I spent five years looking for the right spot and waiting for the right day," he says. From November to March, prime soaring season, he studied day-to-day fluctuations in wind direction and jet stream location. "I talked to my weatherman at least once a day, sometimes twice."

On February 17, 1986, Harris saw on the weather map an extremely strong high-reaching wave above the Sierras. He headed for the California City airport and had his single-place Burkhardt Grob G-102 sailplane towed to 12,500 feet over the entrance to the Owens Valley at Inyokern.

Having thrashed through the rotor, Harris thought the worst was over. The G-102 circled and climbed northward easily for two and a half hours, and Harris considered shooting for 50,000 feet. But as he neared the mark and the oxygen mask went to full pressure, he had trouble mastering the proper breathing technique. The temperature in the unheated, unpressurized glider was minus 85 degrees Fahrenheit, and the canopy was completely iced over. Tears were freezing on his cheeks. "I wasn't in pain," he explains, "but I began to have little popping sensations in my head and it felt like worms were crawling up my legs."

Harris checked the altimeter. It read 47,000 feet, but he estimated that at such an altitude it lagged by at least 1,000 feet. He knew he had broken the record. The sealed barograph on board later indicated he had reached 49,009 feet.

After a grueling descent through the rotor, Harris relaxed, sure that the ordeal had finally ended. But at Inyokern, the wind was blowing at 50 mph. "To get to my home field in California City," he recalls, "I had to be towed back up through the rotor again," Harris says. "That was it for me."

Since then, he has flown only three times, choosing to take a larger role in ground crew operations for other fliers. He crews for Ingrid Köhler, who hopes to break the 41,460-foot altitude record for women, and also for Jim Myer, a former Air Force U-2 pilot who will attempt to take Harris' sailplane to 50,000 feet.

"I may go up again, but not in rotor conditions," Harris says. "I guess it's a case of burnout."

—Kent Hannon

Back-to-School Special

Every school day 16-year-old Curtiss Aldrich wakes up at 6:00 a.m., sticks his head out the bedroom window, and checks the sky. If it's clear, he hops back into bed and goes back to sleep.

Meanwhile, his classmates are scurrying to get ready. They have an hour's bus journey on the narrow, winding road from their homes in Groveland, just outside Yosemite National Park, to Sonora High School, deep in California Gold Rush country. At 6:30, about the time they're boarding the bus, Curtiss finally gets up.

By 7:00 a.m. he's out preflighting the 1959 Cessna 150 he owns with his father. At 7:15 he lands at Columbia Airport, 20 miles northwest, ties down the Cessna, and waits for a school bus to take him the last three miles. If he had a car at the airport he could sleep another 15 minutes and still get to school on time.

"It's nice to be able to sleep in," says Curtiss, who got his student pilot's license on April 23, his 16th birthday, "and flying is more interesting—and more fun—than riding a bus. And you're more in control."

Curtiss lives with his parents at Pine Mountain Lake, an aviation community built around an airstrip nestled in the Sierra Nevada foothills. Curtiss' father, John, sells antique aircraft memorabilia. He named his son Curtiss Ried, after the Curtiss-Reed propeller on his 1941 Waco UPF-7 biplane. Curtiss and his grandfather, 78-year-old Harry Aldrich, picked up the youngest- and oldest-pilot awards at several California airshows this summer.

Curtiss wants to attend the U.S. Air Force Academy in Colorado Springs after he graduates from high school in 1989. Meanwhile, he pumps gas at Pine Mountain Airport, washes airplanes, and sells aviation lapel pins to pay for half the Cessna's upkeep.

Now he's wondering if he should get a car. "The weather will probably be bad for

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a couple of months," he says, "so I could keep the car here instead of at Columbia Airport and just drive to school—but I'd rather fly."

The next milestone in Curtiss' aviation career will be his 17th birthday, when he'll be old enough to earn his private pilot's license and carry passengers. Will he use the Cessna when he starts dating? "Yeah, I could. It's a two-seater." Gee, what a way to get to the prom.

—Elaine de Man

Orphaned

In May, the Aircraft Owners and Pilots Association hosted a meeting in Washington. It was a somber gathering.

The pilots, Federal Aviation Administration people, and aircraft industry representatives huddled in conference rooms were discussing the dwindling supply of aircraft parts, a problem that threatens to ground thousands of light airplanes. As general aviation aircraft production seems to spiral toward a black hole, many replacement parts now come from salvaged wrecks rather than the factory.

The parts crunch is a side effect of the decline that has weakened the industry and orphaned many airplanes that were among the most popular in general aviation's heyday. "In the old days, our distributors handled the entire parts-support business. [Now] we're orphans ourselves," said Doug Smith, Piper's administrator of parts development.

In the old days—10 years ago—sales of 14,000 airplanes constituted a fair year, and dealers bought everything the Big Three—Cessna, Beech, and Piper—could build. This year, perhaps 1,000 aircraft will be sold. Some owners have made more money selling their airplanes piecemeal rather than intact.

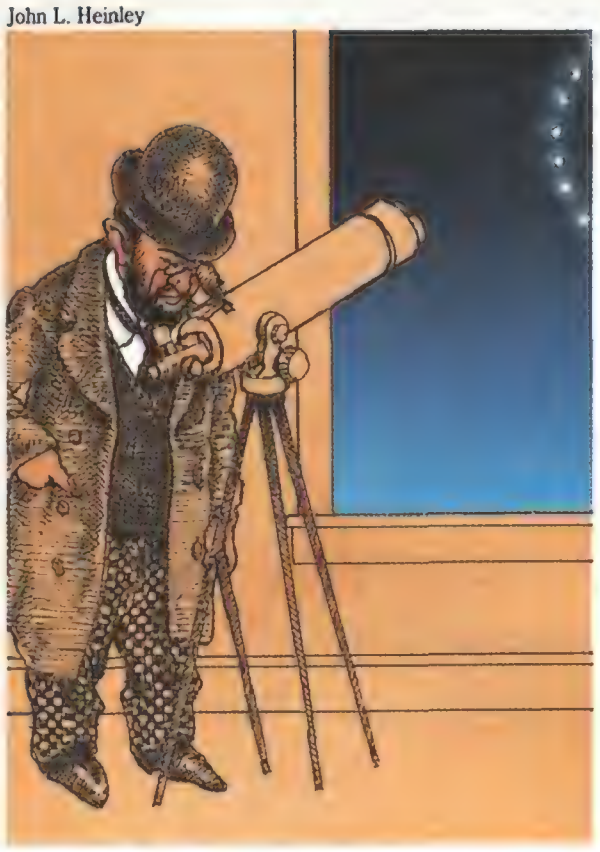
Light airplane owners are coping—just barely—by turning to methods that have sustained fanciers of classic cars: they salvage, they fabricate, and they pay absurdly high prices for the few factory parts that are available. Pilots who bought older airplanes because of the price break find themselves classified as antiquers. For missionary organizations that use airplanes to maintain lifelines in the Third World, the scarcity of parts is more serious.

—George C. Larson

Update

The orbital art project proposed by France's Tour Eiffel company (Groundling's Notebook, June/July 1987) has caused howls of protest from the world's astronomers, who say it will interfere with

John L. Heinley



nighttime observations, particularly photography of faint galaxies. Plans call for a 1989 launch of either a ring of reflective spheres or a reflective sail into low Earth orbit in celebration of the Eiffel Tower centennial. However, both the French and European space agencies say they will not provide technical or financial support, making the project's feasibility questionable.

Astronomers at the Harvard-Smithsonian Center for Astrophysics ("Farsighted Astronomers," August/September 1987) have discovered a pair of quasars that are either colliding with or circling each other at the edge of the visible universe, some 12 billion light-years away. Quasars, thought to be bright cores of forming galaxies, are a rare occurrence, and Smithsonian Observatory scientists say that "having two so close together would be unprecedented."

Dorothy Michele Novick

A fleet of tilt-rotor aircraft (Soundings, October/November 1986) could capture 64 percent of the New York-to-Boston travel market, according to a government study.

Industry leaders met on Capitol Hill last July to hear reports on the feasibility of tilt-rotors serving high-density short-haul routes. The report emphasized that the tilt-rotor's success in the civil market hinges on the avoidance of airport and airway congestion. Roy Lobosco of the Port Authority of New York and New Jersey said a total of 11 two- to four-acre vertiports in New York and Boston could make the tilt-rotor competitive with fixed-wing service.

A hundred monkeys on board a China Air cargo flight to New York turned the trip into a flying circus (Soundings, June/July 1987). After landing at Kennedy International on July 30, the crew radioed for help in cornering a macaque running amok. ASPCA employee John Schneider spent 90 minutes chasing the monkey up and down the airplane. "Meanwhile, all the monkeys were cheering her on," Schneider said. Glimpsing light from a window, the macaque leapt against it, stunning herself long enough for Schneider to grab her. "She was feisty, angry, and jet-lagged," he reported.

An error in Newton's *Principia* (Anniversaries, June/July 1987) has been discovered by a 23-year-old physics student. Robert Garisto, now a graduate student at the University of Michigan, found that in a calculation used to determine planetary mass, Newton used 11 seconds of arc rather than the accepted 10.5 to define the angle between two lines running from Earth to sun. (Scientists today use an angle of 8.8 seconds.) "Newton plugged the wrong value into a calculation," said Garisto, who was a senior at the University of Chicago when he found the error in the 300-year-old work last spring. "It certainly doesn't change history's view of him."

Shares of stock in Heathrow and six other airports are now for sale by the British government. British Airports Authority shares are priced at approximately $4. The sale of BAA is another step in a program to transfer government-owned assets to the public. British Airways and Rolls-Royce shares were also recently made available.

A British Airways Concorde was responsible for two broken ankles, three fractures, and numerous sprains and car crashes on May 22. A charter flight into Leeds-Bradford Airport at Wakefield, Yorkshire, so startled residents that they stumbled, tripped over, and drove into one another while gazing skyward.

—Patricia Trenner

In Search of Miracles

"Smoking or non?" the woman at the airline counter asks.

"Non," I reply. "And window."

Why do I ask for that? Why can't I get with it? *Aisle* is the seat to request. There you can stretch, walk around, get your jacket out of the overhead bin. Asking for window is about as dumb as asking for the middle—the seat that stays empty until two seconds before the door is shut, and then, just when you're eyeing it the way Hitler did Czechoslovakia, an enormous person lugging a bale of upholstery samples hurries aboard, and with sweaty apologies, beats you to the invasion.

I started going for the window seat back when I was in the service. Knowing the way many transport pilots fly, I felt that by keeping watch on our impending doom, I might be able to shout out a last-minute suggestion, like "Switch tanks!"

One night after I had become a civilian, I took a flight that ended up plunging through a thunderstorm. I sat at my window, white-knuckled, as lightning lit up the darkened cabin in flashes. None of the passengers seemed to mind except me. Then the great man himself, El Capitan, came down the aisle, noticed me, and inched his way into the adjoining seat (airplanes weren't always full in those days).

"You must be an old pilot," he said. "You're the only passenger who's awake. Terrifying, isn't it?" And there, at 20,000 feet, we began talking about horrendous storms and close calls.

Those innocent days of air travel, when passengers and crew shared the sense of adventure, have gone the way of air navigation by light beacon. But my window seat habit is firmly established. I pay heavily for it.

I must arrive early and burrow into my place, or else find myself making my own sweaty apologies to my seatmates, to the people in the aisle whom I'm blocking, and to the attendant for holding things up. Once in, I'm there for good. (Warning: Never pass up a restroom on your way to a window seat.)

My favorite magazine is gone by the time the attendant with the selection makes it

Illustrations by Hank Caruso

over to me. And when seated by the window, I find that attendants can't hear my drink order unless I shout (first I try murmuring, then hissing). These days, that's embarrassing: I like a vodka martini before badgering my stomach with airline food, and no one else seems to drink anything but diet cola—or worse. I get the same look that, in my youth, I used on seedy old men in railroad coaches who drank out of bottles in brown paper bags. To passengers nowadays, that's what *I* am.

Asking for a drink when you're alone on a flight is especially suspect. If only my wife flew with me more often. She would be close enough to the attendant to lean over and, with a twinkle, ask for two vodka martinis. The attendant would grin

conspiratorially and deliver the goods.

It was after I finally got my martini on a flight home from Chicago that I really looked hard at my addiction to this seat. The minuses are overwhelming. But sometimes—just sometimes—I see an exquisite, prolonged sunset over the Pacific, a crystal-clear eagle's view of canyon patterns etched on the Southwestern desert, a sweeping abstraction formed by contour plowing in the Midwest, a blaze of brilliant fall foliage cloaking New England hillsides.

While we were letting down toward the airport at Baltimore, I looked out at the Chesapeake, spotting some of the very places I had once sailed. That's another advantage of a window seat: it provides a wonderfully fresh look at familiar scenes.

We got to the terminal and I stood up, stooping uncomfortably under the overhead baggage compartment, waiting for the endless jam of impatient passengers to pass, one by one, through the cabin door. Suddenly I felt as though I were teeing off at golf—back bent, head down, eyes dully fixed, though not on a ball but on the weave of my neighbor's shirt. And I realized that I take the window seat for the same reason that I try to play golf: to search for miracles.

In one case it's the screaming straight drive after dozens of slices. It's the approach that lofts over the intervening trees and thuds onto the green, instead of into the trap. It's the 40-foot putt that follows the contours and bongs neatly into the cup, instead of sizzling eight feet past it.

The frustrations of the window seat are as miserable as golf's. But the rewards—the view of unmarked snow packed between peaks in the Rockies, the arrowing wake of a boat on a calm lake, the salmon-pink contrail of a distant airliner passing at sunrise—make it worth coming back with the same answer at the counter: "Non-smoking; window."

When I walked into the terminal, I found my wife waiting for me. "How was the flight?" she asked.

"The last hole went very well," I said.

—Edwards Park

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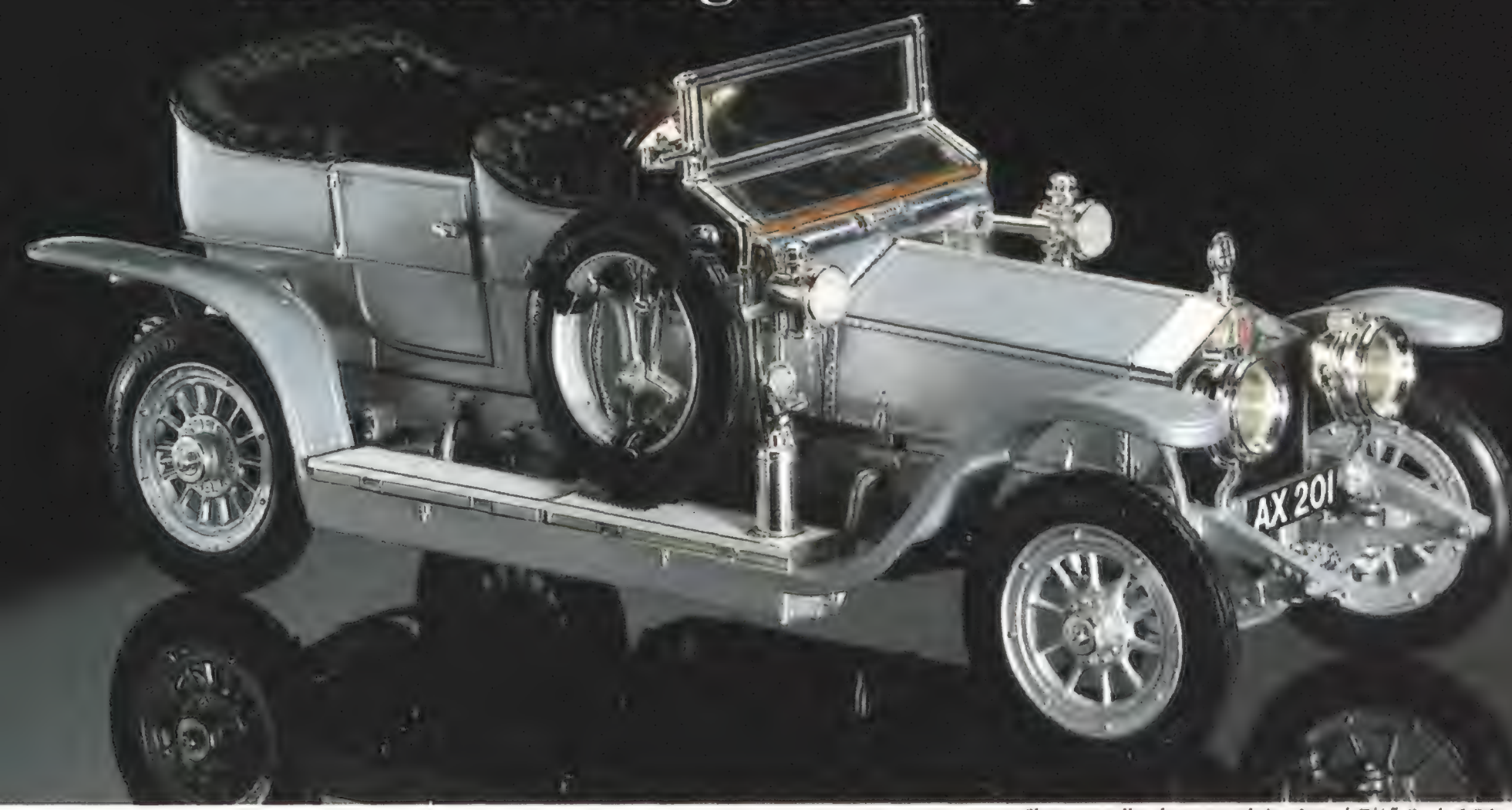

Shown smaller than actual size. Length 7¾". Scale 1:24

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Anniversaries . . .

1799
November 12 In a boat off the Florida Keys, Andrew Ellicott observes a meteor shower—probably the peak of the 10-week-long North Taurids minor shower—and writes in his journal: "The whole heaven appeared as if illuminated with sky rockets, flying in an infinity of directions, and I was in constant expectation of some of them falling on the vessel. They continued until put out by the light of the sun after day break."

1890
October 9 At an estate in Gretz-Armainvilliers, France, electrical engineer Clément Adler makes a hop of 165 feet in the first full-size piloted airplane, the steam-powered *Éole* monoplane. Over the next seven years, Adler developed two more machines, neither of which succeeded in making a sustained, controlled flight.

1907
November 13 Paul Cornu makes the first untethered helicopter flight—20 seconds, to an altitude of six feet—at Lisieux, France. The twin-rotor vehicle, powered by a 24-hp engine, proved far too unstable for sustained flight.

NASM

Enmeshed in his helicopter, Paul Cornu hovered for 20 seconds in 1907 (left).

1929
October 18 France launches the large submarine *Surcouf*, which carries a reconnaissance seaplane with folded wings in a watertight hangar. The submarine sank in 1942 in the Gulf of Mexico after being accidentally rammed by a U.S. freighter.

NASM

The Do X could have taxied across the Atlantic faster than it flew the route on a 1930-1931 trip.

1930
November 2 The huge 12-engine Dornier Do X flying boat leaves Freidrichshafen, Germany, for New York, via Africa and South America. It arrived 10 months later, delayed by wing damage in Lisbon and hull damage in the Canary Islands.

1938
October 22 Lieutenant Colonel Mario Pezzi reaches 56,046 feet in a Caproni CA 161 biplane at Montecélio, Italy, setting an altitude record for piston-engine aircraft that still stands.

1954
November 30 Mrs. Elizabeth Hodges is struck by a 10-pound chunk of a chondrite meteorite in Sylacauga, Alabama. Mrs. Hodges had been napping on the sofa when a meteorite plummeted through the roof of her house, hit a radio set, bounced off her hip, and landed on the floor. Mr. Hewlett Hodges offered to sell the seven-inch meteorite to the highest bidder, but the Air Force claimed the fragment for research. Mrs. Hodges was left with only a hole in the roof and an enormous bruise.

1955
October 1 The U.S. Navy kicks off the age of the supercarrier with the commissioning of the USS *Forrestal*, the first designed for jet aircraft.

1959
October 7 The Soviet satellite Luna 3 transmits the first pictures of the far side of the moon. The absence of major plains, compared with the terrain on the near side, was evident even in these crude images.

1961
October 14 The North America Aerospace Defense Command conducts "Sky Shield II," a defense exercise that involves thousands of military aircraft and grounds all commercial flights for 12 hours. It was an exercise, a NORAD spokesman recalled, "as big as sliced bread and chunky peanut butter."

October 21 An amendment to the Civil Air Regulations makes airline management

An altitude record set by a 1938 Caproni biplane has yet to be topped.

NASM

rather than the captain of the flight responsible for banning intoxicated passengers from boarding. The new rule allowed the captain to pay more attention to preflighting the aircraft and less to preflighting passengers.

1962
October 3 The Mercury capsule *Sigma 7*, piloted by U.S. Navy Captain Walter M. Schirra, is launched from Cape Canaveral. During NASA's fifth manned space mission,

NASM

Walter Schirra's Mercury flight was nearly aborted seconds after liftoff.

controllers briefly considered separating the capsule (which would land via parachute) and destroying the Atlas D launcher, since its roll rate after liftoff seemed dangerously high. The decision to abort was aborted, and Schirra made six orbits during the flight. He learned of his close call only after landing.

1964
October 30 NASA X-15 pilot Joseph Walker makes a one-minute flight in the Bell Aerosystems Lunar Landing Research Vehicle, rising to 10 feet. Its variable stability allowed pilots to rehearse for lunar operations.

1965
November 26 With the launch of the Matra A-1 from the Hammaguir Range in Algeria, France becomes the third nation to place a satellite in Earth orbit. The spacecraft, similar to the United States' Vanguard, was designed to operate for two weeks. The primary purpose of the exercise was to test the Diamant booster.

1970
October 26 NASA representatives meet their Soviet counterparts in Moscow to discuss compatible space rendezvous and docking systems.

1971
October 11 The world's first space station, Salyut 1, launched in April, is taken out of orbit and disintegrates as it enters Earth's atmosphere. Salyut 1 was occupied

Sovfoto

A Soyuz crew camped out for three weeks in the world's first space station.

for three weeks by the crew of Soyuz 11, who all perished when depressurization occurred during separation from the space station.

November 18 U.S. Public Law 92-159 provides criminal penalties for anyone who harasses, shoots, or attempts to shoot wildlife from an aircraft.

1974
November 15 Spain's first satellite, INTASAT 1, is launched from Vandenberg Air Force Base in California. INTASAT 1, which provided ionospheric electron counts, hitched a ride on a Delta rocket along with a U.S. weather satellite and the amateur radio operators' satellite OSCAR 7.

1981
November 12 The *Double Eagle V* and a four-man crew led by Ben Abruzzo complete the first manned crossing of the Pacific via balloon. The flight, which took 85 hours, covered 5,768 miles from Nagashima, Japan, to Covelo, California.

The Double Eagle V wafted from Japan to California—right into a thunderstorm.

Dick Kent

. . . and Events

Through October 12 "Twenty-five Years of Manned Space Flight," Smithsonian Traveling Exhibition. At Children's Museum of Oak Ridge, TN, (615) 482-1074.

Through October 15 "Black Wings: The American Black in Aviation," Smithsonian Traveling Exhibition. At Massachusetts Port Authority, Logan Airport, Boston, MA, (617) 561-1628.

October 3 & 4 Willow Run Air Show. Blue Angels, hot-air balloons, antique and aerobatic aircraft. At Willow Run Airport, Ypsilanti, MI, (313) 482-8888.

Christopher Springmann

Patch as patch can at October's Albuquerque Balloon Fiesta.

October 3–11 Albuquerque, New Mexico International Balloon Fiesta. Airshow, parade, and a whole bunch of balloons. (505) 344-3501.

October 3–24 "Jupiter and Its Moons," Smithsonian Traveling Exhibition. At Bemidji Community Arts Center, Bemidji, MN, (218) 751-7570.

October 8 "Women in Aviation," lecture by Claudia Oakes of the National Air and

NASM

The legend of Jacqueline Cochran shines in a "Women in Aviation" lecture.

Space Museum. At Montana State Historical Society, Helena, MT. Smithsonian National Associates, (202) 357-1350.

October 8–11 "Airsho '87," annual Confederate Air Force demonstration. At Rio Grande Valley International Airport, Harlingen, TX, (512) 425-1057.

"Liftoff over the Pacific," annual Aerospace Education Conference. Tour Vandenberg Air Force Base and launch complex. Santa Maria Airport Hilton, Santa Maria, CA. U.S. Air Force Civil Air Patrol, (916) 364-4550.

October 10 "The Golden Age of Flight," lecture by Claudia Oakes of the National Air and Space Museum. At Rocky Mountain College, Billings, MT. Smithsonian National Associates, (202) 357-1350.

October 14 "Winged Wonders: The Story of the Flying Wing" and "Behind the Scenes at the National Air and Space Museum," seminar and lecture by E.T. Wooldridge. At University of Montana, Missoula, MT. Smithsonian National Associates, (202) 357-1350.

October 15 "Behind the Scenes at the National Air and Space Museum," lecture by E.T. Wooldridge. At Montana State University, Bozeman, MT. Smithsonian National Associates, (202) 357-1350.

October 16 & 17 "Technical Advancements in Naval Aviation" and "Man's Quest for Wings: Aviation History," lecture and seminar by National Air and Space Museum curators. At Museum of Flight, Seattle, WA. Smithsonian National Associates, (202) 357-1350.

October 16–18 Third annual Midwest Space Development Conference, with astronaut Bonnie Dunbar as featured speaker. Discussion topics include a manned mission to Mars, returning to the moon, the search for extraterrestrial intelligence, and the development of religion, morals, and ethics in space. At Holiday Inn Northwest, Worthington, OH. MSDC, (614) 459-0847.

October 18–November 15 "Black Wings: The American Black in Aviation," Smithsonian Traveling Exhibition. At Massachusetts Transportation Building, Boston, MA, (617) 973-7200.

October 19 Hurricane Thanksgiving Day in the U.S. Virgin Islands celebrates the end of the hurricane season.

October 21 Orionid meteor shower, average of 25 per hour. Two to three hours before sunrise. *

October 23–25 Annual Astronomy Jubilee. Celestial poetry, astronomical sing-along, early-morning cosmic nature walk, observatory tour, lectures, Hubble Space Telescope movie. Custer Institute Astronomy Group, Southold, NY, (516) 757-7501.

October 24 & 25 Open Cockpit Weekend. World War II and contemporary fighters, bombers, and helicopters are open to visitors. At New England Air Museum, Bradley International Airport, Windsor Locks, CT, (203) 623-3305.

Blue Angels airshows feature two F-18s attempting to merge into an F-36.

U.S. Navy

November 6 "Telescopes for Everyone," workshop by Geoffrey Chester, National Air and Space Museum. At the Children's Museum, Minneapolis, MN. Smithsonian National Associates, (202) 357-1350.

Geoff Chester

Hold the universe in a tennis-ball can at the Children's Museum in Minneapolis.

November 7 & 8 Miami Air Show. Blue Angels, Golden Knights, Concorde, Harrier, F-14, antique aircraft, aerobatics, wingwalkers. At Opa Locka Airport, Miami, FL, (305) 685-7025.

November 8 Edwards Air Force Base annual open house. Thunderbirds, Air Force Flight Test Center aircraft demonstrations, ground displays of operational, test, and antique aircraft. Chuck Yeager will demonstrate supersonic flight to commemorate two 40th anniversaries: the breaking of the sound barrier and the formation of the Air Force. At Edwards, CA, (805) 277-3510.

November 8–15 Guiana Space Center tour. Visit Martinique, Cayenne, Devil's Island, and the Ariane launch facilities at Kourou, French Guiana. National Space Society, (202) 543-1900.

November 18 Leonid meteor shower, average of 15 per hour. Two to three hours before sunrise. *

International Launches
October Arianespace, Guiana Space Center, French Guiana: German TV satellite, via an Ariane 2 launcher.

** Call the Smithsonian Earth and Space Report for recorded information on astronomical events at (202) 357-2000.*

Organizations wishing to have events published in Calendar should submit them four months in advance to Calendar, Air & Space/Smithsonian, *National Air and Space Museum, Washington, DC 20560. Events will be listed as space allows.*

—Patricia Trenner

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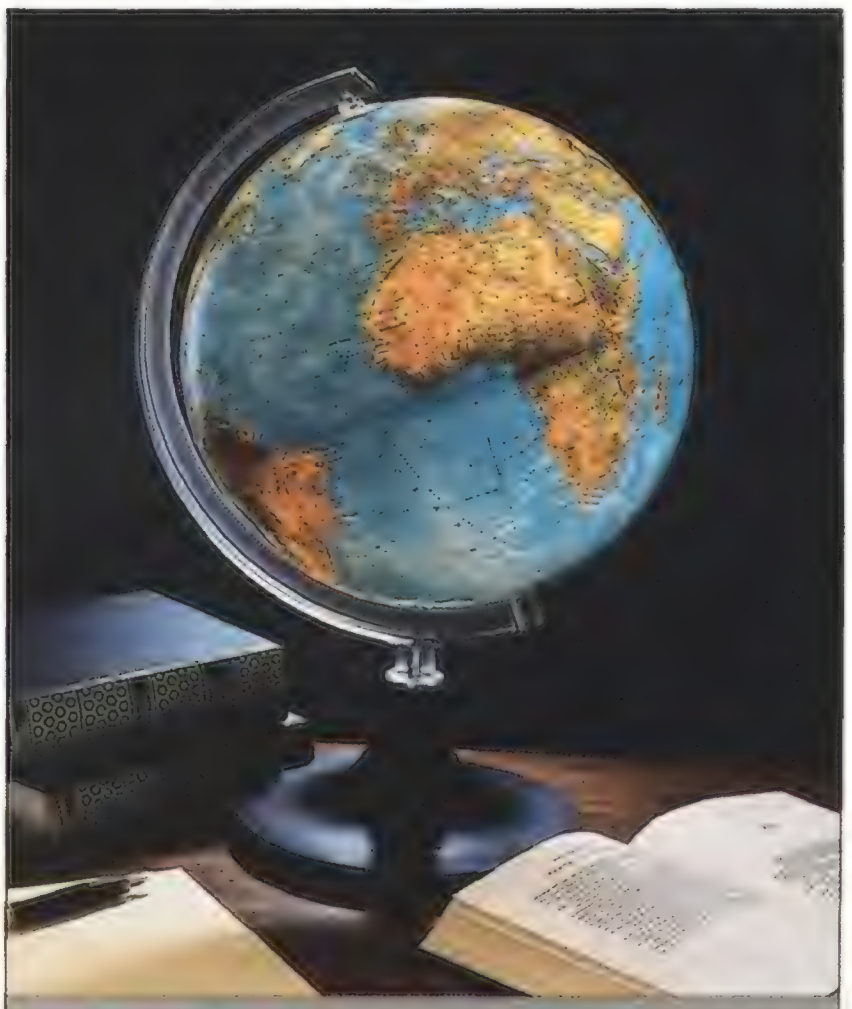

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On Exhibits

Museum exhibits used to be little more than unorganized collections of objects gathering dust behind glass. That's not the case at the National Air and Space Museum: the exhibits tell stories, not merely about technology, but also about the cultural context of aerospace history. The Golden Age of Flight Gallery moves beyond its airplanes by using period music and newsreels to recreate the mood of the period between the two world wars, while the Looking at Earth Gallery shows how and why we study our planet from above. The product of years of planning and the work of dozens of people, a gallery can cost more than a million dollars.

"We try to make the exhibits as exciting as possible," says Nadya Makovenyi, assistant director of the Exhibits Department. "The curator tries to get as much information as possible out to the public, and we're here to try to make sure that information is something the visitor will understand, and maybe whet their appetite for more."

The biggest job for Exhibits during the next few years is a new gallery illustrating the impact of computers on aerospace technology (Viewport, *Air & Space/ Smithsonian*, July/August 1987), scheduled to open in May 1989. It will feature a full-scale mockup of the Grumman X-29, an airplane so unstable it couldn't be flown without its computers. Also on display will be a Rockwell HiMat (Highly Maneuverable Aircraft Technology), an unmanned research airplane designed to test fighter aircraft technology. The QN, engineer Paul MacCready's flying model of a *Quetzalcoatlus northropi* pterosaur, will hang at the entrance. A Link trainer, an early pilot training simulator, will be juxtaposed with a space shuttle simulator. The gallery will also have a spare Mariner 10 and a Cray supercomputer, the first computer to simulate fluid dynamics realistically. In addition, visitors will find a number of computers that they will be able to use themselves to gain hands-on experience designing an aircraft or even a space station.

Paul Ceruzzi, the gallery's curator, is in charge of its content. He is working closely with designer William Jacobs, who is responsible for the exhibits' presentation. "[Jacobs] may suggest that an artifact I want to use won't look right," says Ceruzzi. "My initial feeling is I don't care what something looks like, if it's historically valuable it belongs in the gallery." In shaping exhibits, compromise is vital.

The people in the Exhibits Department stress the importance of teamwork in a gallery project. Project coordinators Victor Govier and Sandy Rittenhouse-Black work to ensure that the gallery comes in on time and on budget. Jim O'Neil is working on software design, while Patricia Woodside is producing the gallery's films and videos. Edna Owens will edit the labels that explain the objects in the gallery. At the Paul E. Garber Facility in Suitland, Maryland, the production crew will construct the walls, cases, cabinets, and other bits and pieces of the new gallery's structure.

There's also a lot of paperwork involved as a gallery evolves. It begins as a proposal, develops into a concept design, and ends up a detailed planning document. Each step has to be approved by various Smithsonian and Museum officials. Nothing is left to chance. "We don't just say, 'We want an X-29,' " says Makovenyi. "Everything has been checked out. It requires a lot of homework." Before deciding to include the X-29 mockup, the Exhibits staff first had to determine if the crane needed to hoist it into place could even be moved onto the second floor.

Because so many landmarks in the development of computer technology have been reached in the last ten years, Ceruzzi and Jacobs decided not to arrange the computer gallery chronologically. Instead they are concentrating on seven categories—design, aerodynamics, manufacturing, flight testing, air operations, flight simulators, and space operations—and emphasizing how the computer has changed each.

The gallery's subject matter posed another big problem. Ceruzzi admits, "Basically, computer stuff is the most boring stuff to look at. There's no way to get it exciting just by showing one computer after another." Part of the solution was to use interactive computer software.

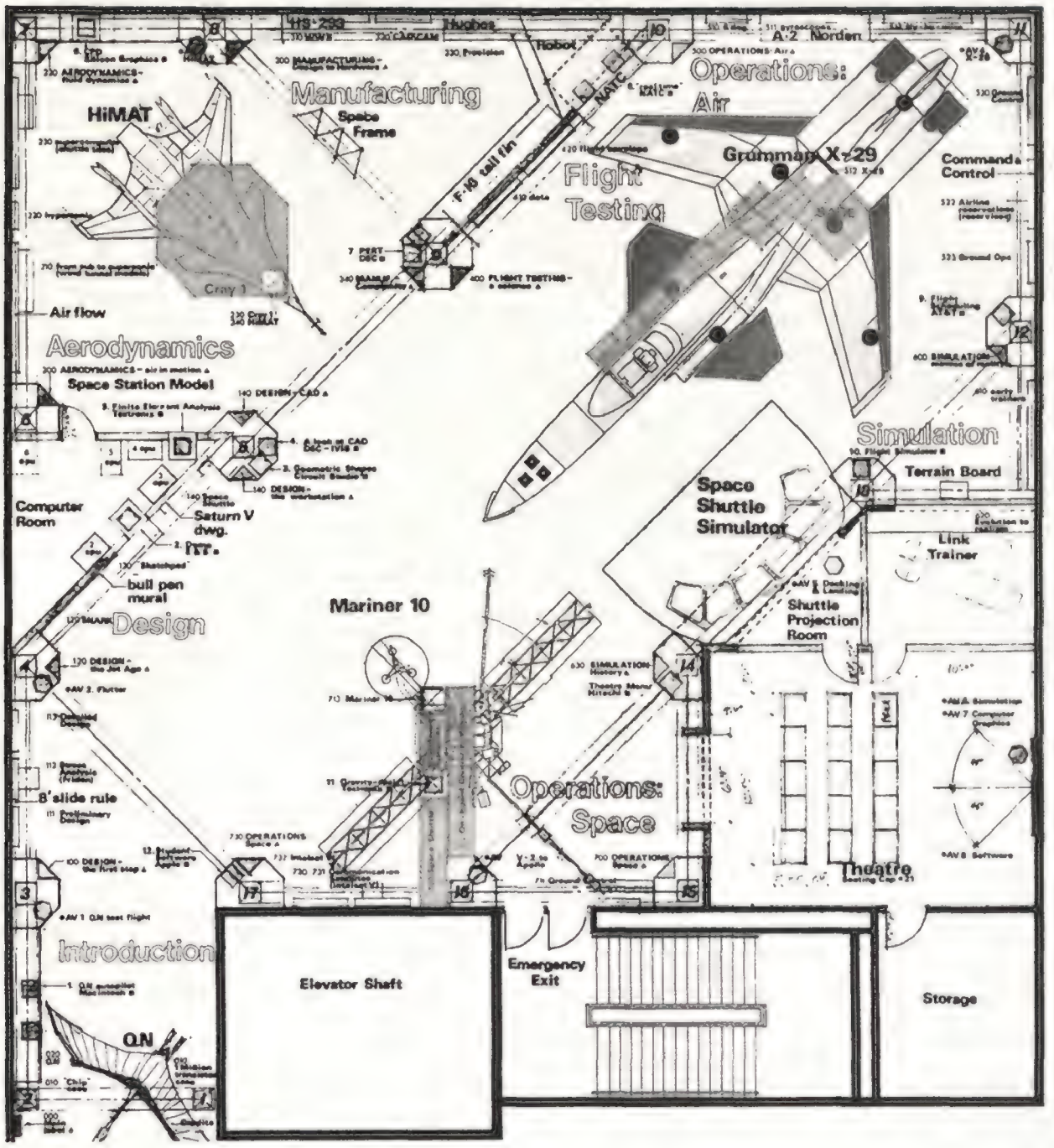
But the interactives created their own problems. Computers require additional power. They generate heat. The light level has to be low enough so visitors can read the screens but bright enough so they can read the exhibit labels. The terminals have to be spaced properly to prevent crowds from forming.

Practical demands such as these help shape a gallery. To make the computers

If it weren't for computers, the Grumman X-29 wouldn't fly. The airplane's electronics keep the basically unstable craft under control.

Grumman Corporation

NASM



The design of a gallery must take into account practical, educational, and aesthetic concerns.

accessible for periodic maintenance, the Exhibits team decided to run the cables through a truss system designed to resemble the frame of the proposed U.S. space station. In addition to its utilitarian role, the truss will give the gallery a fittingly modern look.

Lighting is another important element of design. "The concept in the computer gallery is to have everything appear like a lightning bug. In other words, the light emanates from it," says Frank Florentine, the Museum's lighting designer. "We're going for a very white look underneath benches and kiosks, positioning lights below them to give a feeling of lift." The lighting of the truss system will evoke the way it would appear in space—bright and without shadows.

Because light is a relentless enemy of museum artifacts, Florentine also has to balance conflicting concerns: display and conservation. "No matter what you do, you're going to have some degradation of the artifact," Florentine says. The idea is to minimize such effects. Filters can eliminate the most damaging wavelengths, and light levels are kept low in some galleries.

But when visitors walk from bright galleries to dark ones, it takes time for their eyes to adjust. A recent exhibit on Halley's Comet included some sixth century books that couldn't be exposed to bright lights. The books were placed in the gallery's rear "so by the time you reached them your eyes had adjusted," Florentine says.

Once the myriad details have been taken care of, the project shifts into the production phase: the old exhibits are removed and the new ones installed. "The most exciting part is the actual production," says Makovenyi. "You see that all of the time, all the meetings, all that paperwork is finally being transformed into something three-dimensional. Every day you go down to the gallery and there's something new there."

After some five months of production work, the aerospace computing gallery will open to the public. It will then be updated periodically to keep the software and hardware current and functioning.

Another project the Exhibits Department is undertaking is a redesign of the World War I Gallery. Designed as a temporary exhibit, the gallery had been moved over from the Arts and Industries Building for the Museum's opening in 1976. With a low light level and large number of woolen uniforms, sandbags, and wooden pieces, "over 10 years it became terribly infested with bugs and moths," says Makovenyi. "The uniforms were being eaten right off the mannequins. The only way that we could stop it was to completely seal off the gallery and dismantle everything."

The gallery was recently reopened, but for now it contains only the airplanes. It will be expanded beyond the current display, but not for a few years. "We have to shoehorn that into our existing schedule, because we usually plan exhibits five years in advance," says Makovenyi.

Other projects on Exhibits' schedule include updating the Sea-Air Operations Gallery, opening a new art show next year, creating exhibits on airplane and helicopter pioneer Igor Sikorsky and the U.S. Customs Service, and installing the world-circling airplane *Voyager* in the Milestones of Flight Gallery.

In the meantime, the aerospace computing gallery inches toward completion. With only a year and a half left before the opening, there's a lot to do.

—Tom Huntington

Out of the Rocking Chair

It hasn't been the quietest retirement for the orbiter *Enterprise*. The craft, designed solely for glide-landing and other tests and incapable of being launched into space, sits on a concrete slab at Washington Dulles International Airport in northern Virginia. Donated to the Museum by the National Aeronautics and Space Administration in 1985 (In the Museum, April/May 1986), the *Enterprise* still works occasionally for its old bosses. For two hot weeks last June, contingents from several NASA field centers gathered at Dulles to use the *Enterprise* for the testing of a new shuttle landing apparatus and as a featured player in a ground crew training film.

The landing apparatus, called an orbiter arresting system, would be used to snare a shuttle on a runway in an emergency—if the brakes failed, for instance. The device, which looks like a giant's volleyball net, is similar to arresting gear for military

NASA

In an emergency, the orbiter arresting system could have a great net worth for a space shuttle.

aircraft making emergency landings.

Engineers performed the test to determine how well the net would engage an orbiter—whether, for instance, it would tear off landing gear doors in a high-speed catch (it would) or rip off the pods protecting the maneuvering system and cause an explosion (it wouldn't). The system is designed to stop an orbiter traveling at up to 115 mph, but for the Dulles test, a wrecker towed the *Enterprise* very slowly into the net.

The uneventful week of testing left the *Enterprise* with no more than some chipped paint. And thanks to three safety engineers on site, the only human injury occurred when one of the safety people, holding a ladder for a colleague, had his fingers stepped on.

After the test, the crew from the system's contractor, All American Engineering, took its shuttle catcher back to headquarters in Newark, Delaware. It may be sent back to the manufacturing plant in Ireland to be upgraded into an operational system that could be installed at runways and launch-abort landing strips around the world.

The film company StellaCom Incorporated of Houston, along with NASA and Air Force personnel, moved onto the scene next to make its training film. Intended to teach emergency astronaut rescue procedures to ground crews, the movie will star astronauts Carl Meade and Dave Low and Rockwell engineer Phil Mongan. The filming took two days. "There was a lot of sitting around both days," says Derek Elliott, the Museum's curator of manned spacecraft, but "there were times it was pretty exciting."

NASA has recently used the *Enterprise* for measurements and fittings for crew ejection systems. And NASA's Goddard Space Flight Center wants to use the orbiter to study how vibration affects payloads in the cargo bay. Sometimes retirement isn't all it's cracked up to be.

—Linda Billings

Space Mail

When faced with an air or space question, people often write to the Museum for an answer. Some write to the Aeronautics Department, hoping the curators can identify an airplane in an old photograph. Others write to offer an artifact. Sometimes schoolchildren request information for a report.

Of the Museum's departments, Space Science and Exploration can probably lay claim to the strangest mail. People write with stories about contact with beings from other worlds. Others seek financing for voyages to the moon, or describe their plans for terraforming the planets. One writer was convinced that inhabitants of the lost continent of Atlantis had created Jupiter's Great Red Spot.

Moon rocks fascinate many writers. Some doubt the authenticity of the rock in the Milestones of Flight Gallery, while one youngster wrote to request 25 cents' worth of moon dust so he would be able to show it to his children. Another correspondent, after reading that scientists had estimated the age of the moon at three and a half billion years, begged to differ. According to the Bible, the writer stated, the moon rock could be no more than 10,000 years old. "Stick to facts," he admonished.

Letters about the television show "Star Trek" form a category of their own. Many of the series' fans write about the *Enterprise* model on display, either to request information about it or indicate ways it should be altered. One fan included a lengthy list of items he thought should be included in an entire gallery devoted to the show.

Some questions are easy to answer: one writer asked if the Museum had an alien spaceship hidden in the basement. The answer, unfortunately, is no.

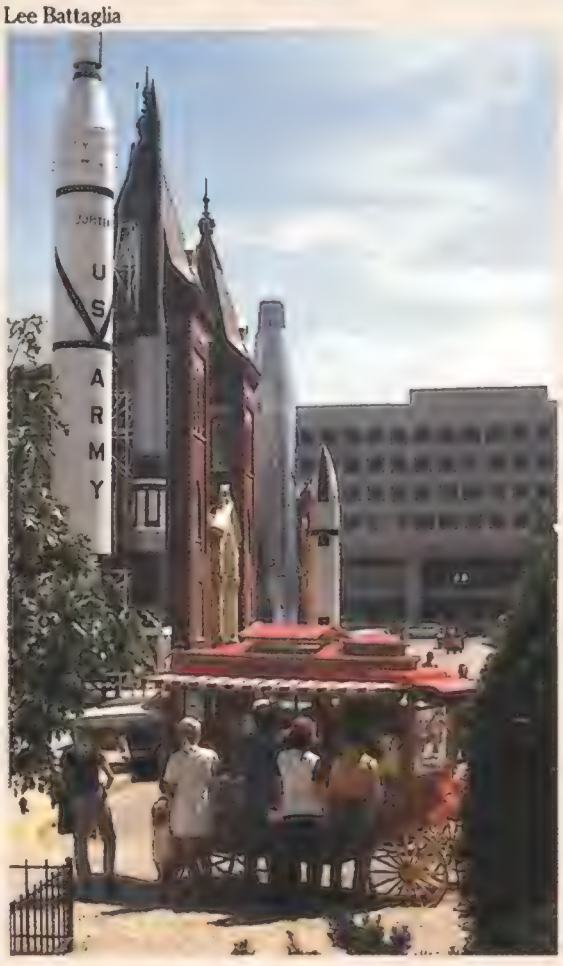
—Tom Huntington

Museum Calendar

Except where noted, no tickets or reservations are required. Call Smithsonian Information at (202) 357-2700 for details.

Focus on Flight: Photography Contest. Entries due by November 30. For

Lee Battaglia



Outside Arts and Industries: that was then (left), this is now.

Now and Then

Before the current Museum building opened in 1976, the national collection of air and space artifacts was scattered around the Smithsonian Institution. Some aircraft were suspended in the Arts and Industries Building. Outside A & I, rockets and missiles stood at attention, facing the official National Air (and—since 1966—Space) Museum building. The prefabricated quonset hut had been erected in 1917.

The rockets and missiles are now in the Museum, and their old vista was recently turned into the Enid A. Haupt Garden. A peaceful setting of flowers, trees, fountains, and park benches, the garden sits atop new subterranean office space and art galleries. Few will disagree that its aesthetics surpass the old hut's.

—Tom Huntington

further information or entry forms, write the Office of Public Affairs, Room 3363, NASM, 6th St. and Independence Ave., Washington, D.C. 20560.

"Aerial Pursuits" Film Series. Fridays, 7:30 p.m., Langley Theater. October 15: *Spirit of St. Louis.* October 23: *Firefox.* October 30: *Command Decision.* November 6: *Catch-22.* November 13: *The Red Tent.* November 30: *The Court-Martial of Billy Mitchell.*

October 3 Monthly Sky Lecture: "The Thrill of Discovery." Gerrit Verschuur, National Radio Astronomy Observatory. Albert Einstein Planetarium, 9:30 a.m.

October 16 General Electric Aviation Lecture: "Faster than Sound." Brigadier General Chuck Yeager, U.S. Air Force (Retired). Langley Theater, 7:30 p.m.

October 20 Lecture: "View from the Stars—Space Photography." Ted Maxwell, Chairman, NASM Center for Earth and Planetary Studies. Quad Auditorium, 7–8 p.m. For ticket information, call the Smithsonian Resident Associates Program at (202) 357-3030.

November 7 Monthly Sky Lecture: "Phases of the Moon." LeRoy Dogget, U.S. Naval Observatory. Albert Einstein Planetarium, 9:30 a.m.

November 8–13 Seminar: "Aircraft Restoration: A Closer Look." For ticket information, call the Smithsonian National Associates Program at (202) 357-1350.

November 19 General Electric Aviation Lecture: "World War II in Europe." Major General Ramsay Potts, U.S. Air Force (Retired). Langley Theater, 7:30 p.m.

The Dachang Douglas

East meets West,
and the common language
is airplanes.

by Charles Barton

In parts of rural China, man and beast still labor in ways that were old when the Great Wall was new. But in Dachang, on the northern outskirts of Shanghai, Chinese engineers and technicians are working side by side with Americans to build McDonnell Douglas MD-82s, advanced twin-jet airliners.

Last April at the factory complex at Dachang, a partially completed MD-82 sat atop yellow hydraulic jacks inside the final assembly facility. Stairs led to its cabin doorways. Scaffolding near the rear of the fuselage served as a platform for workers servicing the two side-mounted engines. Hoses and electrical cables snaked across the concrete floor, past large hydraulic pressure units on each side of the fuselage. The din of the compressors, the clatter of tools, and the staccato rise and fall of voices blended into an industrial symphony.

A red banner spanned scaffolding around the high T-tail. "Strive To Fulfill The Final Assembly Of The First MD-82 In One Hundred Days!" it proclaimed in Chinese and English. Below it a smaller banner read "Follow Approved Tech Data/Procedures To Win FAA Certification."

David Bartruff

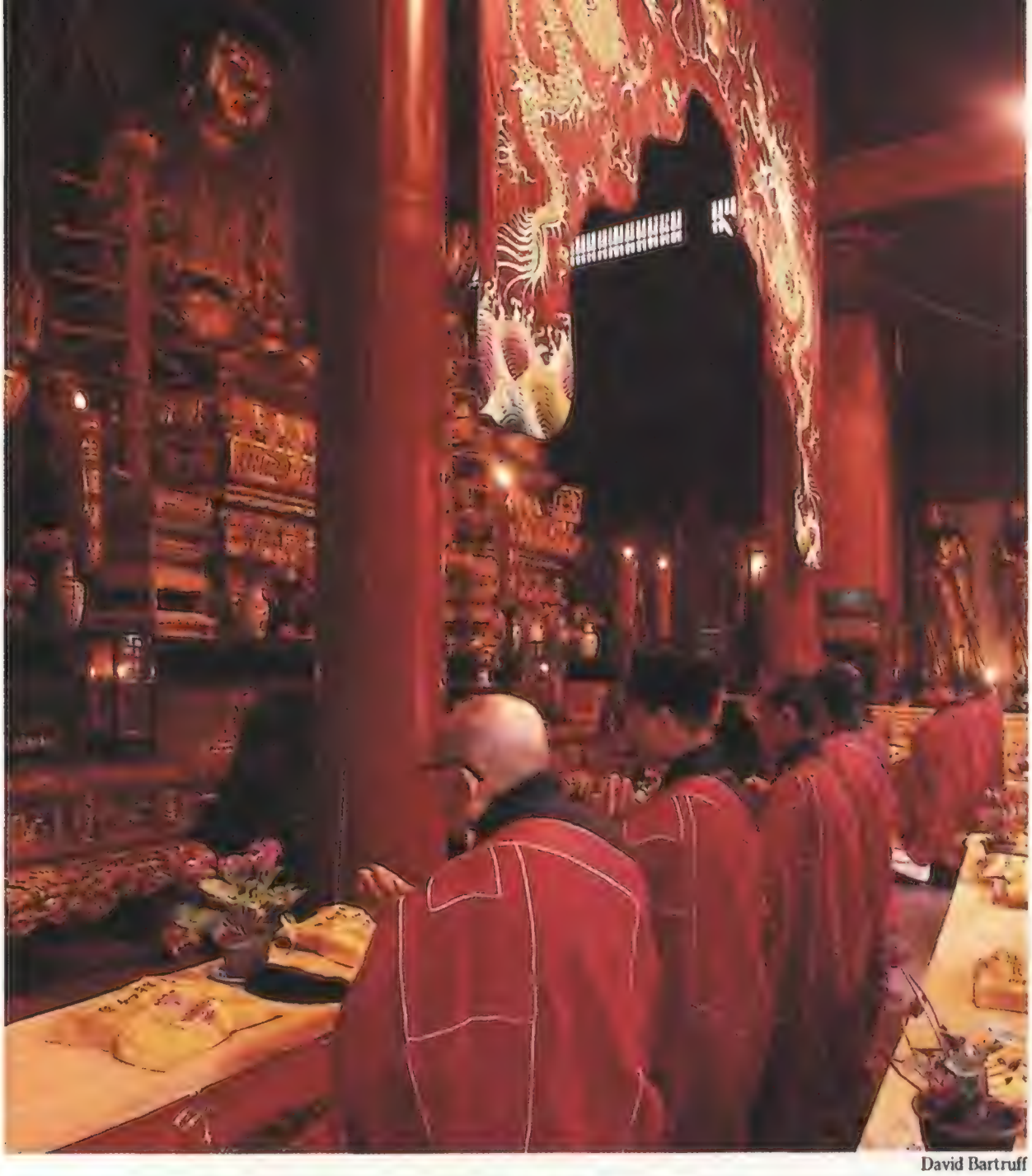
Co-production of McDonnell Douglas MD-82s by Chinese and U.S. partners, which once would have seemed unlikely, generated this emblem.

After training in the United States, Chinese workers were joined by their American counterparts in Shanghai for the start of production.

The MD-82 was the first of 25 to be constructed under a unique co-production agreement between the McDonnell Douglas company and the Shanghai Aviation Industrial Corporation (SAIC). Signed in April 1985, it is the largest single U.S.-China business transaction ever made and one of the major industrial developments of China's Seventh Five-Year Plan, which extends from 1986 through 1990.

The first Chinese MD-82 was rolled out, with little fanfare, last June. Following preliminary flight tests, it was delivered to the Civil Aviation Administration of China in late July. The airplane had taken over a year to assemble, but the Chinese expect to reduce construction time on subsequent MD-82s as they perfect production techniques, and all 25 are scheduled to be finished by 1991. The Chinese also have the option to construct 15 more.

Both sides have high hopes for the deal. The MD-82s, which seat 147 and have a range of over 2,000 miles, will



David Bartruff

Chinese trainees in the U.S. visited Disneyland; Americans in Shanghai had the Jade Buddha Temple.

China's exotic and rugged topography hinders development of surface transportation (left).

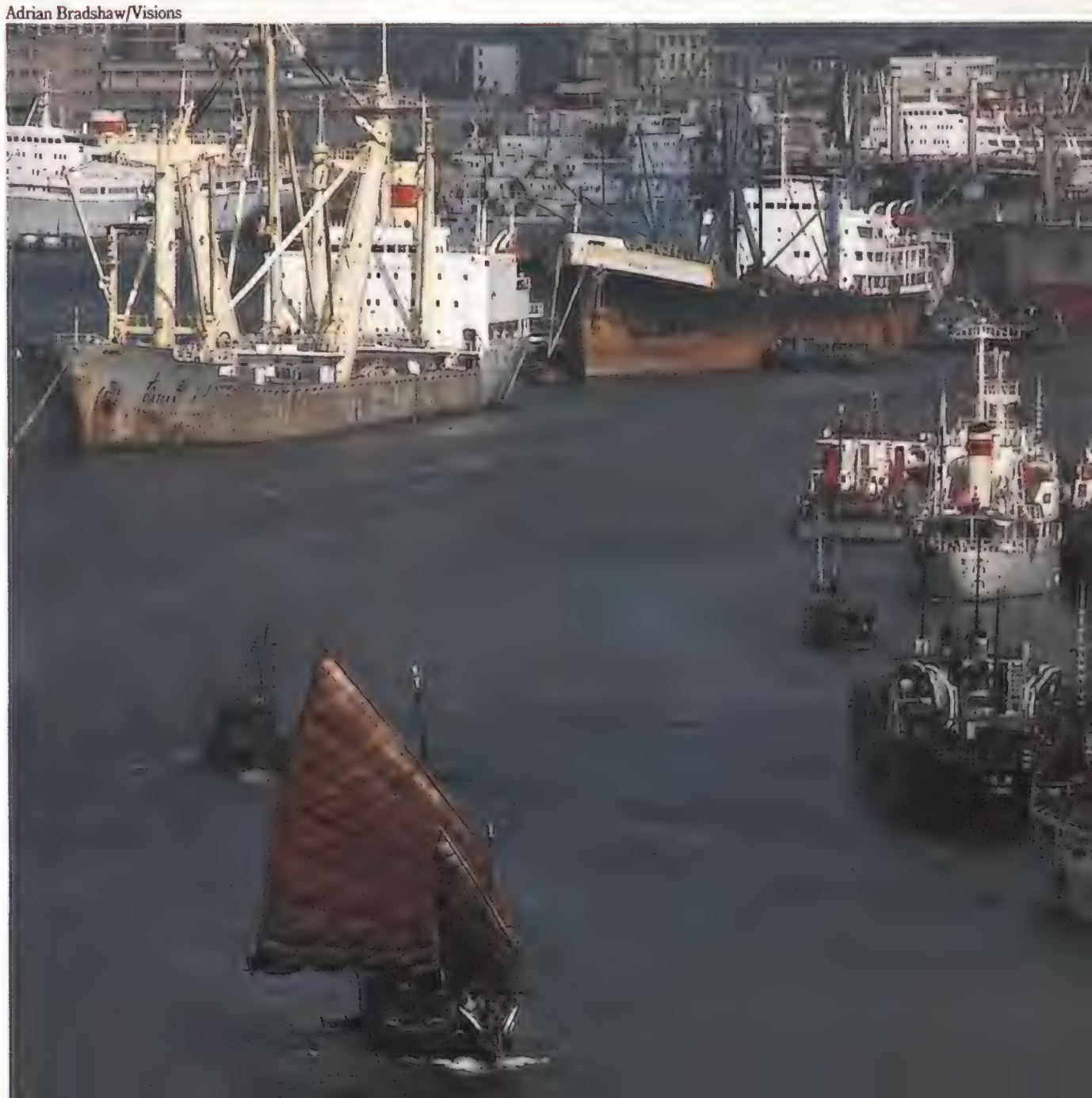
A major seaport, Shanghai will make its mark on air transportation with the production of Dachang MD-82s.

advance the Chinese civil aviation administration's plans for air transportation (see "China's Airline System in an Era of Change," p. 41). Assembling them in Dachang gives Chinese engineers and technicians invaluable training in airplane production. McDonnell Douglas, meanwhile, is eyeing the potential profits of an expanding Chinese market.

The man largely responsible for the co-production deal is the president of McDonnell Douglas China (MDC), Gareth C.C. Chang. Last April Chang spoke about the project's beginnings at his office in Hong Kong. Handsome and articulate, some white showing in his dark hair, Chang wore a tie with the inscription "MD-11," the model number of a new McDonnell Douglas wide-body airliner, the successor to the DC-10.

Before the co-production agreement, China had used the factory at Dachang for aircraft repair work and the construction of two Y-10s, four-engine airplanes with a striking resemblance to the Boeing 707. But the task of building a couple of airplanes differs from that of

Adrian Bradshaw/Visions



The first MD-82 took over a year to produce. But the pace will quicken for the airplanes that follow.

Adrian Bradshaw/Visions

Assembling airliners according to FAA standards requires careful attention to detail and paperwork.

assembling many of them to strict specifications on a production line. "We assumed that because the Shanghai factory had the ability to build and repair airplanes, they had a management system in place," Chang said. "They did, but it differed greatly from ours. It took a year to integrate this Chinese side and the American side into a management system that everyone understands."

MDC's operating arm in Shanghai is McDonnell Douglas China Technical Services, which has been helping the Chinese build the first airplanes. MDC Technical Services has also helped set up a management system that will allow the Chinese to complete MD-82s that can win Federal Aviation Administration airworthiness certificates, just as though they had been constructed at the McDonnell Douglas plant in Long Beach, California.

"Shanghai is now a mirror image of Long Beach," said John Robinson, MDC vice president for operations. "Our procedures, our forms, our engineering systems, manuals, standards, quality assurance, files, computerized shipping and receiving systems, and inventory control have all been put in here. [The workers here] are learning how to meet FAA inspection requirements and build passenger planes that can be accepted internationally. Only a few places in the world can do that." To meet FAA standards, all components for the first MD-82s had to be imported—the wing halves from Canada, fuselage nose sections from Long Beach, and fuselage panels from Italy. After the first six airplanes, China will start fabricating some of its own parts.

The Joint Executive Management Board, composed of Chinese and Americans, oversees integration of the two sides. Chang heads the American side; Yan Huifa, executive president of the SAIC, and Jing Deyuan, SAIC president, head the Chinese.

Jing, who had previously managed a helicopter factory in Harbin, recalled that in the beginning of the co-production, the major obstacles had been the differences in management systems and Chinese inexperience. "Another factor was MDC delay in providing tooling and special test equipment," Jing added. "This is the first time MDC has been involved in such a cooperative venture,

David Bartruff

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so they also lack experience."

The language difference was another problem. Three hundred full-time workers were needed to translate vast numbers of documents. An additional 100 worked to facilitate communication in the factory. In many cases, highly trained Chinese engineers and technicians worked as interpreters to gain experience in airplane production.

Once the agreement was signed, Chinese engineering, quality assurance, and manufacturing personnel traveled to the Long Beach plant for a seven-month training period. (During their time off, they took in Disneyland, a tour of Universal Studios, and the Rose Bowl Parade.)

When the Dachang team returned home, they were followed by some 90 Douglas employees—quality assurance specialists, engineers, manufacturing personnel, and others—who would set up the management systems and help assemble the first airplanes.

On a chilly morning in April, 12 of the Americans straggled out of Shanghai's 26-story Yandan apartment building and climbed into a white Toyota Coaster parked outside the gate. It was 7:30 a.m., 15 minutes before departure to Dachang.

Anthony K. S. Wong, staff specialist in the administrative office, boarded the bus. "Hey, Tony!" someone yelled. "We missed you yesterday. It was really quiet."

Wong had a deep, raspy voice that carried throughout the bus. Fluent in English, Mandarin, Cantonese, and Shanghai dialect, he expedites jobs. "A lot of headaches," he said. For example, when some Americans hungered for

David Bartruff

Upgrading air transportion is important to China. A factory poster indicates other high-priority items.

Adrian Bradshaw/Visions

Frequent meetings allowed both sides to hammer out production details and resolve differences.

David Bartruff

China's Airline System in an Era of Change

China's air transportation system will change and expand.

Air transportation is vital to China, where surface travel is made difficult by rugged terrain that ranges from the mountains of Tibet to the Taklimakan Desert. Ground transportation is inadequate even in the one-third of China that is cultivable. Although not much bigger than the United States and populated with four times the people, China has only one-fifth the railway mileage and few highways. The United States has some 550 airports served by airlines. China's civilian airports number a mere 88.

The situation is slowly changing. Spurred by tourism, trade, and industrial development, China has embarked on an ambitious plan to upgrade its civil air transport system.

The key player is the Civil Aviation Administration of China (CAAC), a 57,000-employee monopoly that has functioned as both regulatory agency and operator of airports, airways, air weather services, and what was formerly the nation's only airline. CAAC, with nearly 150 aircraft of various types, has scheduled service to 22 countries and serves 83 domestic airports.

CAAC has announced a separation of its regulatory and airline functions and the restructuring of the national airline into several regional carriers, but progress has been slow. China has taken steps to pattern its reorganized civil aviation agency after the U.S. Federal Aviation Administration and has adopted FAA aircraft design and certification standards. CAAC's old regional airline administrations are gaining their own identities, and new independent airlines have appeared.

One of the more successful new carriers is United China Airlines, created to utilize unused or underused Chinese Air Force equipment. Since its formation in September 1984, United China Airlines has become a viable money-maker and is often used by foreign tour groups.

But as China's air transport fleet expands—40 new airliners were purchased in 1985—maintaining the sophisticated aircraft becomes a problem. Some work has been subcontracted to airlines and repair facilities outside China, but under an agreement between CAAC and Lufthansa, the German airline is helping CAAC improve its own engineering and technical facilities.

China has also expanded training for flight crews, maintenance technicians, and mechanics for the new aircraft, both overseas and in China. Chinese training facilities include CAAC's Sichuan Flight School at Chengdu, the Beijing Training Center, and the CAAC Training Center at Tianjin, a joint venture established two years ago between the Chinese government and the United Nations Development Program. As part of the McDonnell Douglas co-production agreement, the U.S. company is furnishing MD-80-series flight simulators and helping to establish a flight training center at Hongqiao International Airport in Shanghai, slated to begin operating early next year.

Today, eight of China's civilian airports can be used by Boeing 747s, 13 by Boeing 707s and MD-82s, and 32 by Boeing 737s and British Tridents. During China's Seventh Five-Year Plan, more than 40 airports will be expanded or constructed, with work focused on international terminals and those in regional capitals, important economic areas, tourist cities, and coastal cities. A nationwide ticketing and reservation system is also planned. CAAC deputy director-general Guan De says that by 1990, Chinese airlines will carry 16 million passengers per year, twice the number carried in 1985. That's an average annual increase of 14.5 percent.

Chinese air transportation is on the move, but it has a long way to go.

—Charles Barton

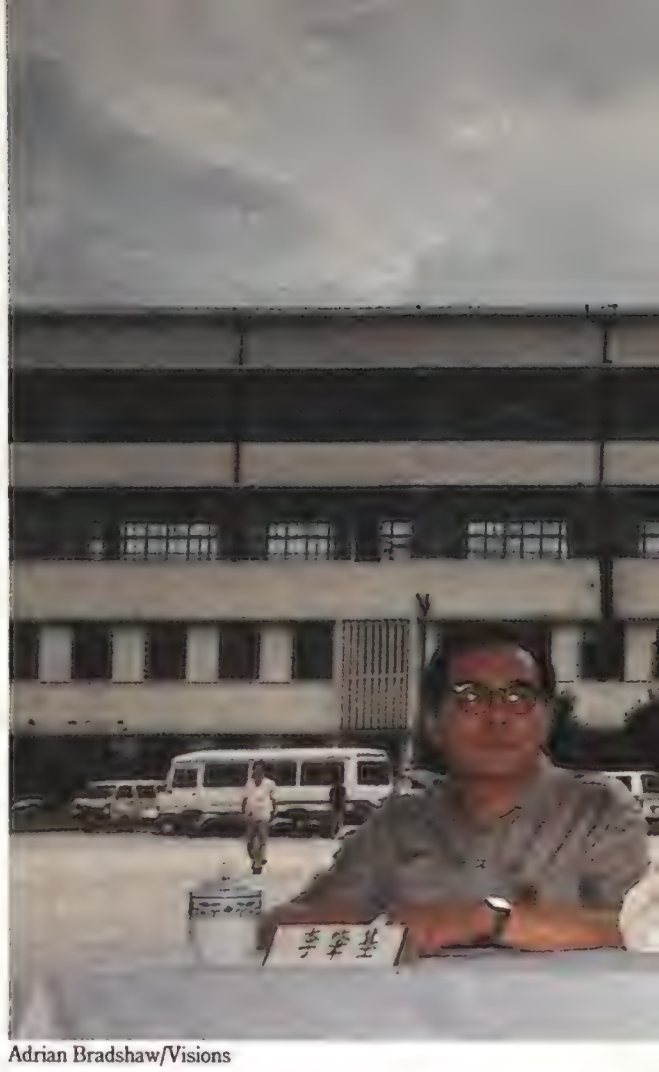
foods unavailable in Shanghai, Wong worked a deal with customs.

"Did you get your food last night?" he asked. "The refrigerated stuff came in by air from Hong Kong on flight 502—a trial run. Seven boxes. Right out of the container and into the cab. The next shipment will be by train. Probably take a little longer because we don't know those people."

Promptly at 7:45 the bus started its 45-minute run, bumping over rough Shanghai streets lined with drab concrete buildings and new construction. There was little grass, but trees grew along some streets. Laundry hung from poles jutting out of windows and from lines tied to trees and posts along the sidewalks. Signs covered with Chinese calligraphy and block characters adorned shop fronts.

By Dachang, city streets had given way to open fields. At the arched factory entrance a guard waved the Toyota through, past the construction of a new training center. A turn onto the facility's central street brought the enormous final assembly facility, Building One, into view. The building faced a concrete ramp area where Chinese and Americans played basketball after lunch in an ongoing competition (the Chinese were ahead). On the right side of the ramp stood Building Two, where the second, third, and fourth airplanes were being assembled.

Amid the tumult of Building One, Virginia Funches, a quality assurance spe-



Adrian Bradshaw/Visions

Adrian Bradshaw/Visions

Adrian Bradshaw/Visions

A traditional McDonnell Douglas tie-cutting ritual marked the transfer of the airliner to its owners (above).

Chinese and American executives and dignitaries attended the July delivery of the first MD-82 (top).

One down, at least 24 to go: the Dachang workers at the ceremony will be busy into the 1990s.

cialist, was working with several Chinese technicians on the first MD-82. When she found a slab of styrofoam taped over openings in the pilot's control pedestal, Funches pointed out the potential hazard of bits of the material falling inside. A Chinese worker removed the styrofoam and vacuumed out the crumbs.

Funches left the cockpit and climbed down the stairs to the shop floor. Her eyes were sparkling. "I love it!" she exclaimed. "I'm proud to be a part of it. It's more than just going to work every day to build an airplane. It's the meeting

of two countries, of two companies, so I go out of my way to be careful because of that."

Building Two housed a high-ceilinged office shared by several McDonnell Douglas engineers. Near the door a small stand supported a thermos of hot water—when thirsty, the Chinese prefer hot water to cold. On the walls hung bilingual charts labeled "MD-82 First Article Flow Chart" and "Second Article Flow Chart," as well as an American flag, a world map, photos of McDonnell Douglas airplanes, and a calendar featuring Chinese dancers and actresses.

At a long table in the room's center, liaison engineer Fred Bialas was teaching technical English to a man and a woman, Chinese engineers Tong Zi Xiong and Li Zhi Zhang. Both had helped design the Y-10.

Bialas' well-trimmed beard and mustache, glasses, and German accent gave him the air of a European scholar, an impression that was enhanced as he slowly dictated a technical essay to his two students. After they read back what they had written, Bialas corrected their pronunciation and offered definitions.

But the education in China hasn't been one-sided. "Anyone who comes to China on a program such as this is in for a big learning experience," said McDonnell Douglas' Charles Nunnelly, who runs the shop training and management development programs in Shanghai. "There's more than one way to skin a cat," he said, "and sometimes we find that they can skin it their way as well as we can ours."

In particular, Nunnelly found that authority is delegated differently in the Chinese management system. "We have fairly clear-cut ideas of who's responsible for what, and in most cases the responsible people are given the authority they need," he said. "But their government is part of everything that happens. The interrelationships are very complex. Sorting out responsibility and authority is very difficult."

Section manager Frank Urso, in Shanghai since September 1986, found a more basic difference between the United States and Shanghai: the bathrooms. In Building Two there is a squat-type hole-in-the-floor toilet and a concrete trench urinal. "I try to wait until I get home," Urso said.

McDonnell Douglas

The MD-82s are eligible for the U.S. FAA airworthiness certificate, a seal of approval worldwide.

Assembly section manager Robert McKinney, a 23-year McDonnell Douglas veteran, arrived in Shanghai in January 1986. "If we finish on schedule it'll be the closest thing to a miracle I know," he said. "When we started they were still building buses in the hangar. But the Chinese have put in a lot of hard work. Now it looks like things are coming together."

The program office at Dachang monitored progress on the first airplane. Lie Lei, a graduate engineer working as a statistician, plotted the latest information on wall charts in the executive control room. She noted with satisfaction that the curves for scheduled and actual completion dates for each step of the assembly process were coming together, thanks in part to the addition of an extra evening shift and a half-day's work on Sundays.

The workmanship was top-notch. "When we put the fuselage halves and bulkheads together—perfect fit," said Joseph A. Benko, director of manufacturing at MDC Technical Services. "No abnormal leaks during the pressure test. Excellent workmanship. We're very pleased.

"But keep in mind the context," Benko continued. "In Long Beach they're building two and a half airplanes a week. Here they're building one in a year, so they can afford to take a little more time. We're doing a wiring integrity test now, testing all the wiring in the airplane. So far we've found only three errors due to workmanship. On a faster line they might find twenty."

Of course, the Chinese aren't entirely different from Americans. There is a noticeable slackening of effort just before quitting time, and the traditional midday ***xiu xi***, or rest period, often means a long lunch break. One American observed that to the Chinese, work is the place you go to for lunch.

During the second week in April, Mo Wenxiang, the minister of aviation industry, and Zhao Ziyang, the premier, made separate visits to the Shanghai factory. They appeared happy with the progress of the co-production effort, which has been a substantial investment for the Chinese. The new 54,000-square-foot warehouse, the heated assembly hangars, pressure test area, training center, and paint facility have all been built or renovated with Chinese money. In John Robinson's opinion, the Chinese are going to have to build more than 25 MD-82s to get their money's worth.

According to the SAIC's Jing Deyuan, the MD-82 project has helped interest the Chinese ministry of aviation industry in producing at least 150 transport aircraft with Western aircraft manufacturers. Proposals must provide for substantial participation by Chinese industry in development, production, and product support, with gradual increase in Chinese participation to reach at least 51 percent.

With the co-production agreement in effect, McDonnell Douglas is in an advantageous position to respond to the Chinese requirements. But Boeing has been an important presence in China during the expansion of the Chinese air transport fleet, and Airbus, too, promises competition.

In any event, American-Chinese cultural cross-pollination will continue into the 1990s. "After we came," said Charles Nunnelly, "the Chinese began changing and we began changing and sometimes I'm not sure who has changed, me or them." Airplanes, it seems, are good at bridging gaps—geographic and cultural.

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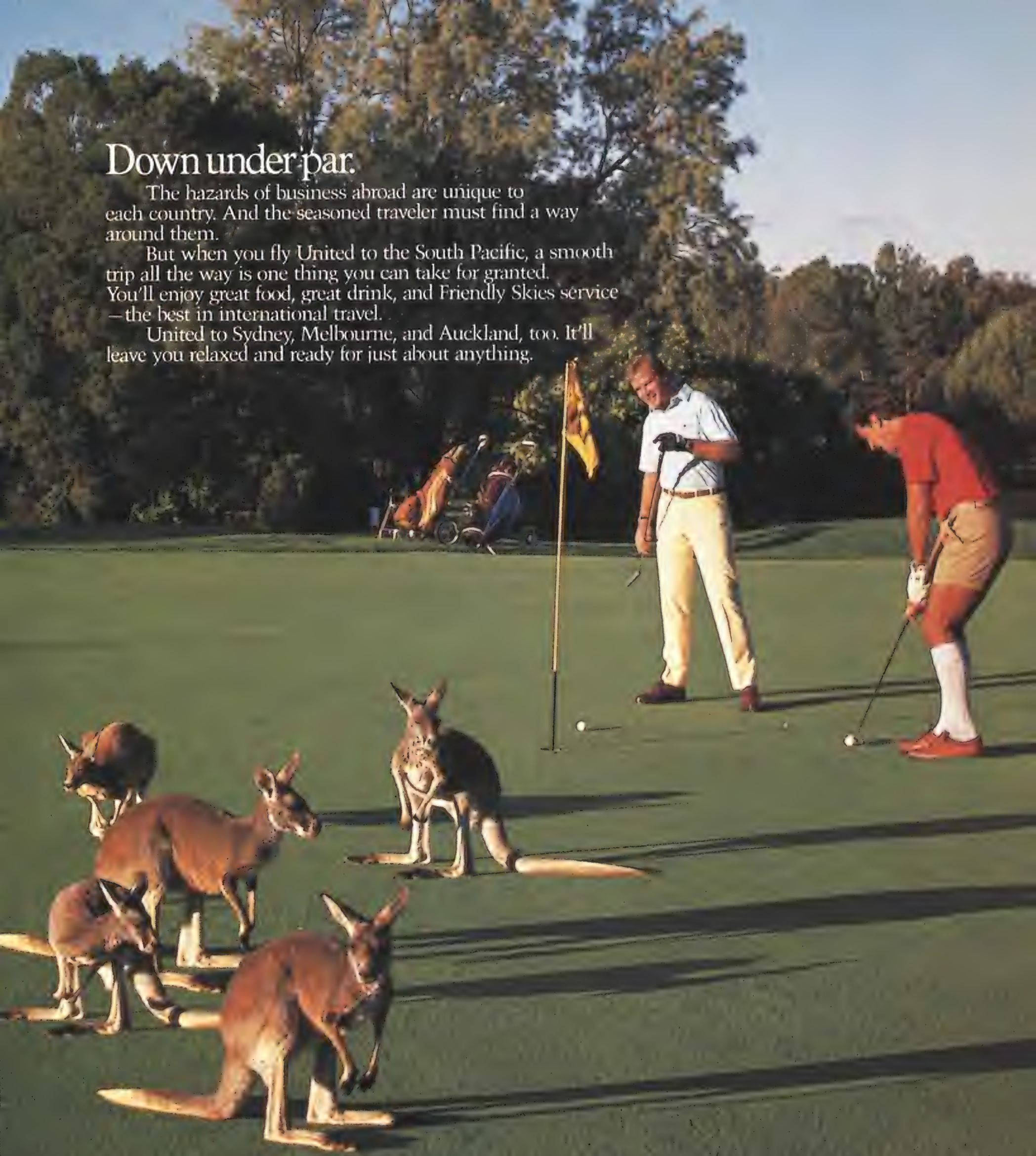

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The Day the Rocket Died

Project Vanguard made headlines for all the wrong reasons.

by Fred Reed

Bettmann Archive

It was an odd year for disaster. The United States ruled the world in supreme confidence. The '57 Chevy, powered by that sweet 283, was the glory of American roads, a symbol of power and opulence. New cases of polio were down significantly for the second year in a row, thanks to the Salk vaccine. Boeing publicized "the only American jetliner now flying—the Boeing 707," claiming that flight aboard the jet was "Quiet. Smooth. Exhilarating!" Elvis crooned and swiveled to the horror of his elders. High school kids bopped, drank beer, and parked on back roads, but in those days even sin had an air of innocence. *West Side Story* opened on Broadway, and the hit summer movie was *A Hatful of Rain*, described by *Time* as "horror in a humdrum living room; with the wifely love of Eva Marie Saint pitted against the dope addiction of Don Murray."

True, there were chinks in the facade. Little Rock exploded in racial violence, and Eisenhower sent in the 101st Airborne to pacify the town. More pervasive was the cold war, grinding along in turgid prose and grisly expectation. Magazines brimmed with overwrought advertisements for military contractors, while news features resorted to personal insults to convey the odiousness of the Red Regime: "Nikita Khrushchev, pudgy, hard-drinking son of Ukrainian peasantry, became dictator of Russia last week, grinning and triumphant after carrying out the most sweeping purge of top-level Kremlin Communists in almost 20 years," *Time* reported in July 1957.

Meanwhile, something called Project Vanguard—few paid much attention to it—was wending its way toward the International Geophysical Year, when it was to launch the world's first satellite. The IGY was to be a period of peaceful international studies of the earth—a welcome relief from the cold war—lasting from June 30, 1957, to December 31, 1958. As it turned out, Project Vanguard would be highly successful, achieving its lofty goal on time and no more over budget than it had to be. But it was also a disaster.

By 1957 the idea of launching a satellite was neither new nor particularly far ahead of contemporary technology. A decade earlier, the RAND Corporation had released a study based on "conservative and realistic engineering" that concluded that a satellite launching vehicle could be built within five years, at a cost of about $150 million. On October 4, 1950, RAND released an updated report to the U.S. Air Force. In his 1985 book . . . *the Heavens and the Earth*, Walter A. McDougall terms this second RAND paper "the birth certificate of American space policy"; it asked not whether a satellite *could* be launched but whether it *should*, and under what conditions. RAND pointed out the potential usefulness of satellites for reconnaissance, while allowing that the Soviet Union might look less than kindly on a U.S. military satellite's flight over Mother Russia. Therefore, RAND recommended that the first U.S. satellite be billed as "experimental" and that it be launched on an equatorial orbit, avoiding the U.S.S.R.

Of course, a simpler way to establish what RAND termed the "freedom of space" principle would be to let a Soviet satellite orbit over the United States before one of ours flew over their country.

The United States seemed to be following RAND's advice when, in late July 1955, a White House press release announced the government's intention to launch, "small earth-circling satellites as part of the United States participation in the International Geophysical Year . . . . [T]he American program will provide scientists of all nations . . . [a] unique opportunity for the advancement of science."

The announcement was hardly greeted with wild acclaim. Most people seemed to think the scheme quixotic and a waste of money. Secretary of Defense Charles Wilson (the same "Engine Charlie" who once told the Senate, "[F]or years I've thought that what was good for our country was good for General Motors, and vice versa," probably an accurate analysis) was asked whether the Russians might beat the Americans into orbit. "I wouldn't care if they did," he responded. (It was later claimed that Wilson favored development of the automatic transmission so that he could drive with one foot in his mouth.) But perhaps the best portent of what would happen when the United States attempted to launch a satellite was the fact that when the White House revealed its agenda, the decision by the requisite committee as to just what sort of "small earth-circling satellites" should be launched and by whom still had not been made.

The Vanguard rocket's three-stage debut was a blowout that exploded hopes for a U.S. space comeback.

Moviegoers flocked to 3D horror shows, apparently unaware of how horrific they themselves appeared (above).

The Stewart Committee, consisting of two members appointed by Assistant Secretary of Defense Donald Quarles and two each appointed by the Army, Navy, and Air Force, had to choose between assigning the nation's space debut to Project Orbiter or to Project Vanguard. A group from the Army Ballistic Missile Agency (ABMA) in Huntsville, Alabama, headed by Wernher von Braun, had suggested strapping some boosters onto a Redstone—a military missile—and going for orbit. That was Project Orbiter. The proposal, right down to its name, had a certain blunt practicality that practically begged for rejection by committee. Politics necessitated a harder way.

The Navy's entry, the more poetically named Project Vanguard, was based on the Viking upper-atmosphere research rockets. The tightly knit Naval Research Laboratory, located in Washington, D.C., had administered the highly successful Viking program since its first launch in 1949. The NRL envisioned using a derivative of the Viking as the first stage of its launching vehicle, and the proposed rocket's obvious scientific lineage went over well with the Stewart Committee. The committee was also impressed with the NRL's elaborate plans for satellite tracking, which featured both a radio system dubbed Minitrack and special cameras.

In August of 1955, the Stewart Committee chose Project Vanguard. The Navy had won the battle. Within two and a half years, it had lost the war.

Despite the apparent ease of launching a satellite, precious few people seemed to suspect that anyone else—the Soviets, for example—might be on the verge of launching one too. Never mind that as early as January 1955, Radio Moscow had announced that a launch would be made "in the not-distant future." Or that in June of 1957, a Soviet delegation visiting the National Academy of Sciences in Washington had told U.S. scientists about the Russian program, and I.P. Bardin had distributed a document entitled "U.S.S.R. Rocket and Earth-Satellite Program for the IGY." Indeed, in its first post-Sputnik issue, *Newsweek* revealed that, "[a]ccording to a Russian-speaking U.S. delegate to the IGY meeting here, the Soviets *did* tell the world last week that their satellite would be launched 'in a matter of days.' In translation, these words of Soviet delegate A.A. Blagonravov became 'in the near future.' So no one paid much attention."

And so, while the country drowsed in innocence, sure it knew who the bad guys were, enjoying postwar prosperity, living an existence full of peculiarly American quirks—the hula hoop lurked just around the corner, and 3D movies were all the rage—a fellow named John Hagen put together a team as best he could. The NRL Vanguard Operations Group never amounted to more than 180 people, including shop hands and clerical help. As an approach to a phenomenal scientific achievement, the first step of humanity off the planet, the enterprise was a trifle casual.

In theory, Project Vanguard was organized on new and path-breaking management principles, but in practice the project followed the accepted pattern of American development,

The Air Force was ready to go hunting with its new Snark missile.

NASM

National Automotive History Collection of the Detroit Public Library

Had you driven a Ford in 1957, it might have been a Fairlane retractable hardtop convertible.

which is to say that no one was quite in charge but everyone had enough influence to make trouble.

The Glenn L. Martin Company, the Viking contractor, almost inevitably got the Vanguard contract and immediately set about upstaging the Navy for the glory, as well as demanding autonomy. Then Martin got the contract to build the airframes for the Titan missile and, to the dismay of the NRL, put many of its best people on this lucrative project. Project Vanguard was, and remained through most of its life, a sideshow, important only to those on the team.

Another problem was posed by the cardinal principle of Congressional politics, which is that to sell anything to Congress, you have to lie about it. Later NASA would become adept at this, selling the space shuttle by promising that it would be as reliable and cheap as a crosstown bus, this being the only way it could get any shuttle at all. The Vanguard team, deliberately or not, had to do some of this. In *Vanguard: A History*, Constance McLaughlin Green and Milton Lomask write, "A decade later perusal of the early discussions of costs might awaken in the reader the suspicion that a lack of candor prevailed among participants fearful lest realistic figures cancel the entire program."

Project Vanguard's real curse, however, was that it was born a bureaucratic orphan. The military services were passionately competing with one another to build ICBMs, chiefly, many thought, for the glory of the respective services, although it was felt that the missiles might also have utility against the Russians. No service wanted to divert attention to nonmilitary ventures into space. As Hagen would later testify before Lyndon Johnson's Senate Preparedness Subcommittee in the wake of the first two Sputnik launchings, "Had we been given top priority and all the things that go with it—men, money, and materials—we certainly could have [launched a satellite] ahead of the Russians."

The plan was to build Vanguard by modifying existing components, thus saving developmental time. The first stage was to be a modified Viking with a General Electric X-405 engine, which would burn liquid oxygen and kerosene to produce 27,000 pounds of thrust. This was just enough to reach orbit. Hagen and Milton Rosen, the Vanguard Operations Group technical director, thought that using 30 percent fluorine and 70 percent liquid oxygen as oxidizer in the first stage might boost thrust to 30,000 pounds. The Martin Company was leery of handling fluorine, however, and there wasn't enough time to experiment. (Using fluorine would have necessitated lining tanks with Teflon, which, apologies to myth, already existed.) Forced to use what was on hand, the team engaged in careful weight-cutting and miniaturization—exercises, incidentally, that would prove useful in future space projects.

The second stage was to be a modified Aerobee-Hi liquid-fueled rocket burning UDMH (unsymmetrical dimethylhydrazine) oxidized by nitric acid. These fuels are hypergolic—they burn spontaneously on being mixed, which eliminates the need for complex ignition devices. A third stage powered by solid

In the days of cold war phobias, the Civil Defense insignia was omnipresent, if not omnipotent.

Fresh off the runways of Paris came sack dresses, prompting understandable dismay.

Wide World Photos

fuel would carry the experimental payload into orbit.

But few Americans knew any of this because few much cared. In Athens, Alabama, the minor vertex of the Huntsville-Decatur-Athens triangle that was, and is, home for the staff of ABMA, the atmosphere was one of complacency. This feeling is hard to recapture. The United States was *the* country in the world, producing almost all of everything worth producing, militarily strong, and filled with such new tokens of moral grandeur as color televisions. We had won the War. True, the schools were poor—not, perhaps, as bad as today's, but that's another story—and teachers and scientists were neither much respected nor well paid. My father, a mathematician at ABMA, managed to feed us, but that was about all. Perhaps the best encapsulation of the national attitude was the face of Alfred E. Neuman grinning from *MAD* magazine: "What, me worry?"

Design specifications for the Vanguard rocket were finished in February of 1956, a year dominated by the Hungarian uprising. The specifications filled 31 pages plus three appendices, about as many as today would be required for a military light switch. Two test flights followed: a Viking rocket outfitted with Vanguard telemetry and Minitrack transmitters on December 8, 1956, and a Viking coupled with a prototype of the Vanguard third stage on May 1, 1957. These tests were understood to be susceptible to failure, always a danger in the early stages of big projects, so all involved were pleased when they went well. In the nation at large, no one noticed.

The third test, in which dummies of the second and third stages would be launched on a live first stage, was scheduled for late October. The first flight of a complete Vanguard vehicle, with three functioning stages topped by a tiny (6.4-inch, 4-pound) test satellite, would take place in December. Finally, in the spring of 1958, the Vanguard team hoped to launch a 20-inch, 21.5-pound scientific satellite into orbit.

But on October 4, 1957, Sputnik took the nation by surprise. Suddenly that arrogant basketball was sailing overhead saying, "Beep-beep-beep." The *Russians*, of all people—stolid people who wore baggy pants and used the wrong fork—had launched the world's first satellite. The shock was profound and the outrage more so. A public that a week earlier had regarded a satellite as foolishness was now furious that it didn't have one.

"Red Moon Over the U.S.," roared *Time*, editorializing frantically over what it referred to as the "chilling beeps" of Sputnik. "U.S. policymakers probably have been seriously under-estimating Russian scientific capability; in vital sectors of the technology race the U.S. may well have lost its precious lead." (The observant will notice that the U.S. has been falling rapidly behind the Soviets for four decades, all the while maintaining its precious lead.) *Newsweek* advised its readers: "Look for Sen. George A. Smathers to win new support for his bill to provide thousands of scholarships for sons of veterans showing scientific and engineering promise." Sexism, needless to say, was still in full flower.

Even to me, a kid of 11 at the time of the launch, the American reaction seemed inconsistent. President Eisen-

A wiggle in the walk and a giggle in the talk—or some such—make the hula hoop go 'round.

Wide World Photos

Bettmann Archive

Oddly, no one ever connected Buddy Holly's hit "That'll Be the Day" with Project Vanguard's satellite-launching attempts.

hower said that the Soviet success was no military danger to the United States (it "does not rouse my apprehensions, not one iota," he declared), which strictly speaking was true. My father and other scientists whose conversation I overheard were rather less sanguine. For one thing, in the race to build ICBMs, a rocket that could put up a payload of 184 pounds had obvious military potential.

A curious mixture of panic, bluff, and pretended unconcern prevailed. A rhyme sticks in my mind: "Twinkle, twinkle little Sputnik / My only comment is so-whatnik?" Soon we would say that Sputnik was evidence of Soviet inferiority: they had to make big rockets because they were too primitive to make small bombs. Later, when Alan Shepard made his suborbital flight after the Russians orbited Yuri Gagarin, we would tell ourselves that our attempt was more productive scientifically. All in all, it was not a dignified performance.

The effect, of course, was that Vanguard, orphaned, unloved, sort of funded, plodding dutifully along, suddenly became the nation's hope. Putting it another way, the country now expected an experimental rocket in a fairly early stage of development to work immediately—much like what was later asked of the shuttle.

On October 9, one of the more lunatic events of the period took place. A somewhat cryptic statement by White House spokesman James Hagerty was misinterpreted by the press to indicate that the December test flight was in fact an attempt to orbit an operational satellite.

What the press release actually said was: "In May of 1957 those charged with the U.S. satellite program determined that small satellite spheres would be launched as test vehicles during 1957 to check the rocketry, instrumentation, and ground stations and that the first fully instrumented satellite vehicle would be launched in March of 1958. The first of these test vehicles is planned to be launched in December of this year." No wonder reporters were confused. They were so confused they almost all overlooked the October 23 test, which of course went beautifully.

To up the ante, the Soviets launched Sputnik 2 on November 3. The 1,121-pound satellite contained the unfortunate dog Laika. In those naive days, the feat led to speculation about an impending Soviet moon-shot. *Time* reported the possibility, adding "and they may try to mark its bright face with a visible splash of red powder." In Hungary, this joke made the rounds: "The Russians are going to the moon!" "What? All of them?"

Now all eyes turned to the Americans' December launch—the Vanguard vehicle's first with three live stages. Although a Vanguard project spokesman said of this preliminary attempt to launch a scaled-down satellite, "We'll be pleased if it goes into orbit. We'll not be despondent if it does not," the press was incapable of such cool reserve. So much hoopla preceded the launch that the Vanguard team decided it had to act as if the shot really was a full-fledged orbital attempt. The stage was set for catastrophe.

And so on December 6, 1957, the nation watched the Great

Sovfoto

It wasn't the Ritz, but Laika seemed perfectly happy with the accommodations aboard Sputnik 2.

Disaster. TV-3 (numbering started at TV-0) stood ready on the launch pad at Cape Canaveral. True, it *might* go into orbit. However, it wasn't especially intended to. Reporters descended in droves. Here was drama: the United States laying its prestige on the line against the rising tide of International Communism (remember, they really talked like that).

When the countdown reached ignition, flames spewed, the engine roared, and the Vanguard launcher rose majestically from pad 18-A, achieving an altitude of several feet. Then it toppled and blew up. The cause was a bad engine start, hardly a fundamental flaw, but the explosion looked highly fundamental on television. That ghastly sag-and-boom burned into my memory and, it seemed, everyone else's. You can't tell a public that has just watched such a flaming snafu that really it was just a bad start, see, a little glitch. Vanguard became a permanent symbol of failure, of American inferiority and incompetence. Inevitably, it became known as Rearguard.

Exactly what went wrong was never determined with certainty, although the telemetry data survived. Technicians for General Electric, which made the engine, concluded that a fuel line above the engine had leaked because employees of the Martin company had used the line as a ladder while working on the rocket. The Martin people decided that low pressure in the fuel tank was responsible.

During the postmortem, Americans did not entirely lose their sense of humor. The Sputnik Cocktail enjoyed a brief vogue at ABMA, at least in conversation: one-third vodka and two-thirds sour grapes. One reader wrote to *Time*, "The U.S. doesn't need an artificial satellite to circle the globe every couple of hours. We've got John Foster Dulles." A *Newsweek* reader suggested voters "re-elect President Eisenhower with the slogan: 'He Kept Us Out of Mars.' " And the Soviets, who were not exactly underplaying their achievement, offered the U.S. help under a program of aid to primitive countries.

Beneath the humor, however, the nation was taking satellites seriously, and was determined that, one way or another, it would have its own beeping ball. In mid-November, even before the Vanguard fiasco, the Army had been directed to proceed with a quickie program to modify a Jupiter-C missile as a four-stage launcher. By late January the vehicle was ready to carry Explorer 1 into space from the Vanguard launching site on the Cape.

General John B. Medaris, commander of ABMA, was taking as few chances as possible. He refused to say exactly when the launch would take place, hoping to avoid a media circus. Problems ensued. Although the weather on January 29 looked good, sounding balloons reported dangerous high-altitude winds, almost certain to destroy the vehicle. The launch was delayed a day. The next day the same thing happened.

Time was running out. The Army had to vacate the launch pad by January 31; the Vanguard team was scheduled to try again on February 3 and needed three days to prepare. And so, at 10:48 p.m. on January 31, with the jet stream calmed to marginal acceptability, the Jupiter-C lifted off. Nobody knew

Courtesy of Life magazine

Life magazine and Liz Taylor were both at the height of their creative powers in 1957.

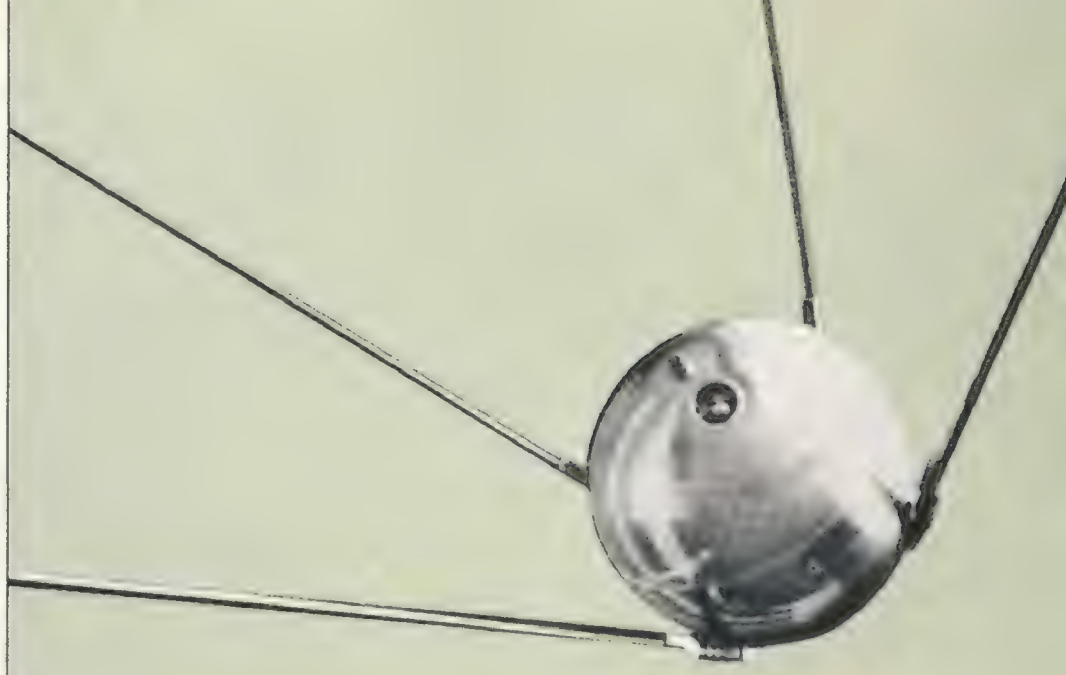
Wide World Photos

The Ike and Dick show continues: President Eisenhower and Vice President Nixon chased the chill of their second Inaugural Parade with hot coffee and Homburgs.

whether Explorer was in orbit until 12:51 a.m., when word came from a tracking station in Goldstone, California: "Goldstone has the bird." The United States had its satellite. The country went more or less wild.

At an open-house the next day, ABMA showed an admiring public all sorts of exhibits predicated on a successful launch. (Had it failed, perhaps the guides would have pointed to the little electric light circling a globe and said, "This is where it *would* have gone.") A Jupiter-C was provided for people to pose with. Despite frigid weather and a high wind, a cute young thing in a bathing suit rushed over to pose, and then dived back into warm clothes. Why, I don't know. Other behavior, more reasonable, was beginning. There was talk of improving the schools. Action actually followed: a massive upgrading of mathematical and scientific schooling that, say some, improved U.S. technological performance for over a decade. My father's salary shot up as the populace discovered a connection between mathematics and beep-beeping.

Thereafter Project Vanguard was forgotten. A Jupiter-C failed to send a second Explorer into space on March 5, but the Jupiter's place in history was nonetheless assured. On March 17, a Vanguard rocket did in fact send a satellite into orbit, and succeeded in two of seven subsequent attempts. In two and a half years, an underfunded and badly supported project had developed a functioning launch vehicle from scratch—an astonishing feat—and indeed achieved a launch in 1958, which was precisely its mission.



Sputnik Remembered

On the never-to-be-forgotten afternoon of 4 October 1957, I boarded an old DC-3, workhorse of the world, in Guam for a military flight to Tokyo. We were 13 in the airplane all told, and I was not only the oldest passenger by far (50), but also the only civilian.

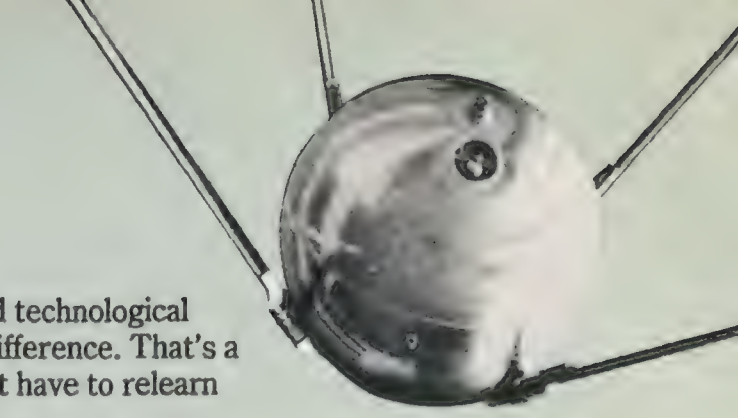
After a refueling stop at Okinawa we reloaded, took off, and sometime after leaving the island ran into a most serious problem with our engines. When it became obvious that we would have to crash-land into a turbulent sea, we all made some last-minute preparations, like tightening our seat belts, putting aside pens, and stowing eyeglasses. We landed with a horrendous bang that pretty well ripped open the fuselage, but the airplane remained afloat for about three minutes, during which time the able enlisted crew got us out the rear door and into the ocean. They also launched a big rubber raft; I became miserably seasick. We had sent off strong signals that were easily triangulated by various stations, and airplanes were sent to rescue us.

When we reached the Iwakuni Base near Tokyo, an excited reporter shouted: "Have you heard the news?" and I called back as spokesman of our group: "Yes. We ditched in the middle of Pacific." He shouted: "No! The Russians have sent a spaceship into orbit around the world." And within minutes we had forgotten our own adventure in the shadow of one so infinitely greater.

—James A. Michener

I was a graduate student at Yerkes Observatory of the University of Chicago, where I was working toward my doctorate in planetary astronomy. The previous year, I had spent time at the McDonald Observatory in Texas during the Mars opposition—when Mars was the closest to Earth it had been in 17 years—peering through the telescope and trying to understand a little of what this neighboring world was like. But there were dust storms on both planets, and I found my convictions reinforced about the limitations to our understanding of other planets when we are stuck beneath this ocean of air on the surface of the Earth.

I was sure that someday spaceflight would be possible, but the announcement of Sputnik 1 caught most of us unaware. I hadn't imagined that the Soviets would beat the United States into Earth orbit. I was startled by the size of the payload



(which American commentators originally stated must have been reported with a misplaced decimal point). Here the satellite was, beeping away, circling the Earth every 90 minutes. My sense of exhilaration was nearly unbounded—it meant that we humans would be going to the planets in my lifetime.

—Carl Sagan

I was a first lieutenant flying a USAF F-86D fighter interceptor in West Germany at the time of Sputnik. I remember thinking that our country better get its act together—that we better make a major push and not get left behind.

—Thomas P. Stafford, Apollo-Soyuz crew

I was a student at Moscow Aviation College at the time. After a lecture we went down to the stadium, where we heard the news about Sputnik.

At first I could not believe it. I thought that it could not happen so soon. But soon I felt great pride for humanity.

—Valery Kubasov, Apollo-Soyuz crew

My reaction to the first man-made object in orbit was one of unalloyed delight. I dismissed entirely any fears that the Soviets, by achieving this feat, now "controlled" the Earth. I knew that its immediate effect would be to move the United States off its big fat bottom and get it to work on its own program of space exploration. And so it did.

As I look back on that day, 30 years ago, it seems to me that we have sunk back onto our big, fat bottom for various reasons and abdicated the cutting edge of space exploration to the Soviet Union, which is slower than we, but also steadier. I hope earnestly that they achieve some astonishing spectacular so that we can again achieve that spasm of urgency we felt in 1957.

—Isaac Asimov

When we were suddenly challenged by Sputnik, I remember being shocked, as most Americans were. We had grown up with an absolute belief in the supremacy—indeed, the omnipotence—of American science and technology. I felt that challenge too, and realized that we had a lot of learning to do in order to reply. Of course, we *did* rise to that challenge, and in most respects, we learned fast and well.

But there's one lesson that has faded from some minds in the 30 years since Sputnik. Too many people seem to have forgotten that a healthy, growing space program requires a strong base of research in science and technology.

Too many people offer only lip service to the importance of fundamental research, but do not give the substantive support necessary to make it happen.

The race for leadership in space is a marathon, not a sprint, and in the long run it will be our strength in scientific research and technological development that will make the difference. That's a lesson from Sputnik we should not have to relearn in every generation.

—John Glenn

In the second week of October, 1957, I was out in the Palm Springs desert, where on the first night of my arrival I looked up and saw Sputnik, that wondrous light, pass over. My heart welled up and brimmed over, as did my eyes. For it was an evening of mixed emotions, happy and sad. My father, my much loved father, was in the hospital dying, and yet here in the sky above me was the purest message of hope for the future for his son and the children of all the people staring up that night at what mankind was capable of doing. I let my soul move along the sky in the dark and could say nothing; there was nothing to say. It was all glory. In the next few nights, I made sure that my father, from his hospital window, saw that fresh beauty in the heavens. It was not easy; he dragged himself there on his own (no help, please) and we talked of that moving light and the far future—and wept together. I was joyful that he saw that incredible illumination in his last days.

—Ray Bradbury

At the time I was a flight test engineer at the Langley Research Center at Langley Field, Virginia. If you can believe it, space was not a subject (outside of Jules Verne) allowed in our library.

What followed at NACA [National Advisory Committee on Aeronautics] was a complete turnaround. Orbital mechanics, re-entry vehicles, and all of the attendant beginnings of venturing into space suddenly were in vogue. JPL [Jet Propulsion Laboratory] put together a lecture series on the solar system and the universe, and it was probably the best attended show in town.

—Christopher C. Kraft Jr., Flight Director, Mercury and Gemini missions

I was a third-year student at Harvard Law School when news came of the launching of Sputnik. It hit the campus like a thunderbolt.

A hall full of anxious law students heard one of their law professors counseling them to be calm, not to panic. He delivered some historical context about competitions between nations. The students wanted to be assured that the U.S. would have a second chance and not be left behind.

I recall being puzzled over the overdrawn nature of the reaction to Sputnik. Did we need Sputnik to document our educational and other deficiencies? Was Sputnik that profound a reflection of Soviet progress? Today, it has taken the "Japanese challenge" to get us to focus on the deplorable state and mindset of overpaid executives mismanaging major U.S. corporations.

—Ralph Nader

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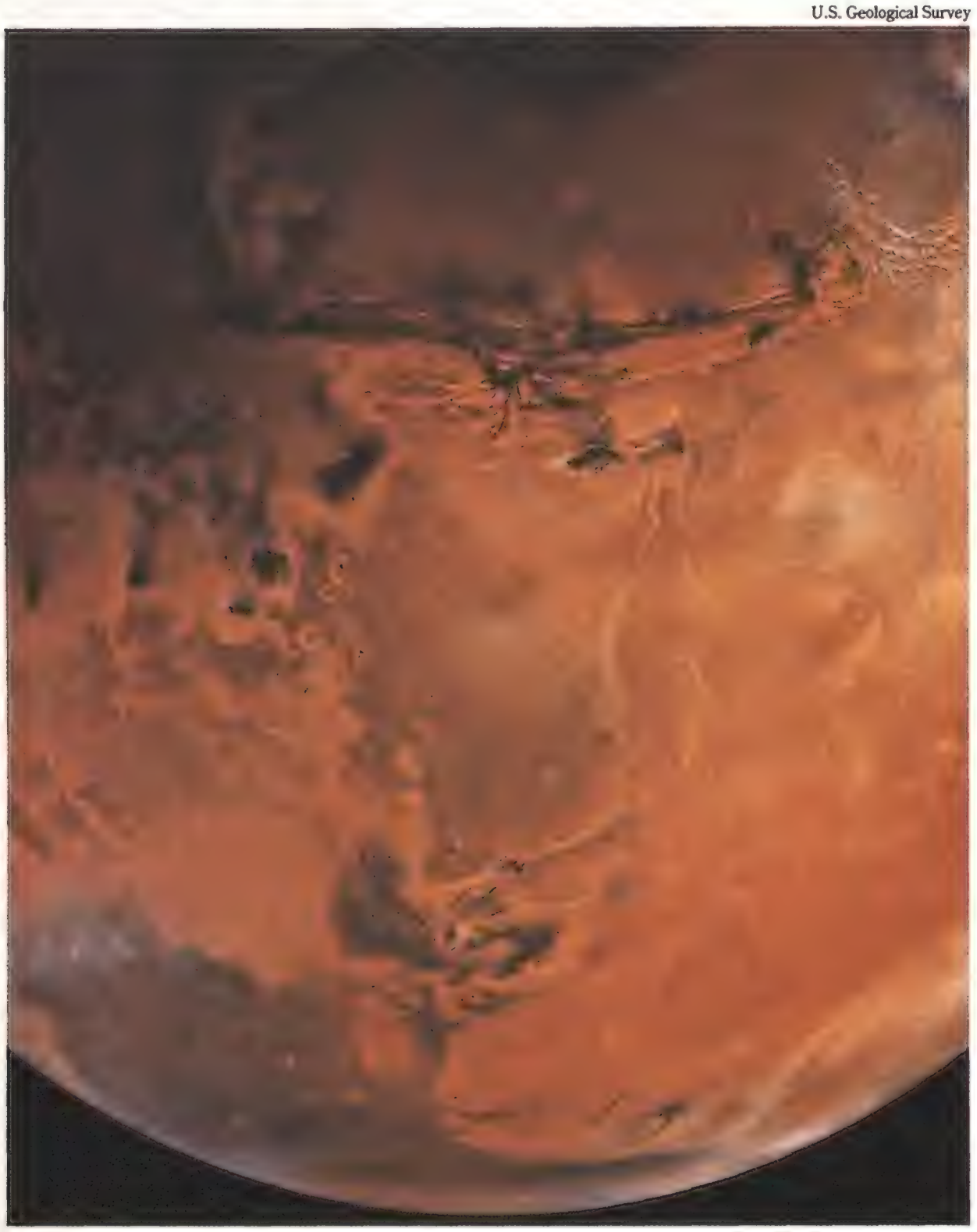
Putting MARS on the Map

On Mars, nobody can hear you ask for directions. But thanks to some space-minded cartographers, now you can reach for a map.

Photographs by Jim Richardson/West Light

by Gary Graf

U.S. Geological Survey



Spacecraft imagery served as the model for a composite picture of Mars, and ultimately a map.

Through the 1960s and '70s, a series of space probes took off from Cape Canaveral on picture taking expeditions to Mars. Today the pictures are yielding information that will end up on maps of the planet's surface. In the 21st century, Earthlings landing on Mars won't worry about getting lost; they'll arrive equipped with maps of the sort familiar to legions of Earthbound backpackers, maps with "U.S. Geological Survey" printed at the bottom.

Since the first Apollo lunar missions of the 1960s, the exploration of the solar system has been a guided tour complete with maps courtesy of the USGS, a down-to-Earth division of the Department of the Interior. The center of the extraterrestrial mapping enterprise is a cluster of nondescript one-story cinderblock buildings on a hill in Flagstaff, Arizona.

The success of a multi-year, multi-million-dollar space mission can depend on the Flagstaff mappers' skills. The USGS offers space scientists and mission planners expert advice along with maps of more than 20 planetary bodies—to date, Mercury, Venus, Earth and its moon, Mars and its two moons,

One of the solar system's most experienced astrogeologists, Hal Masursky is in demand Earthwide.

and several moons of Jupiter, Saturn, and Uranus.

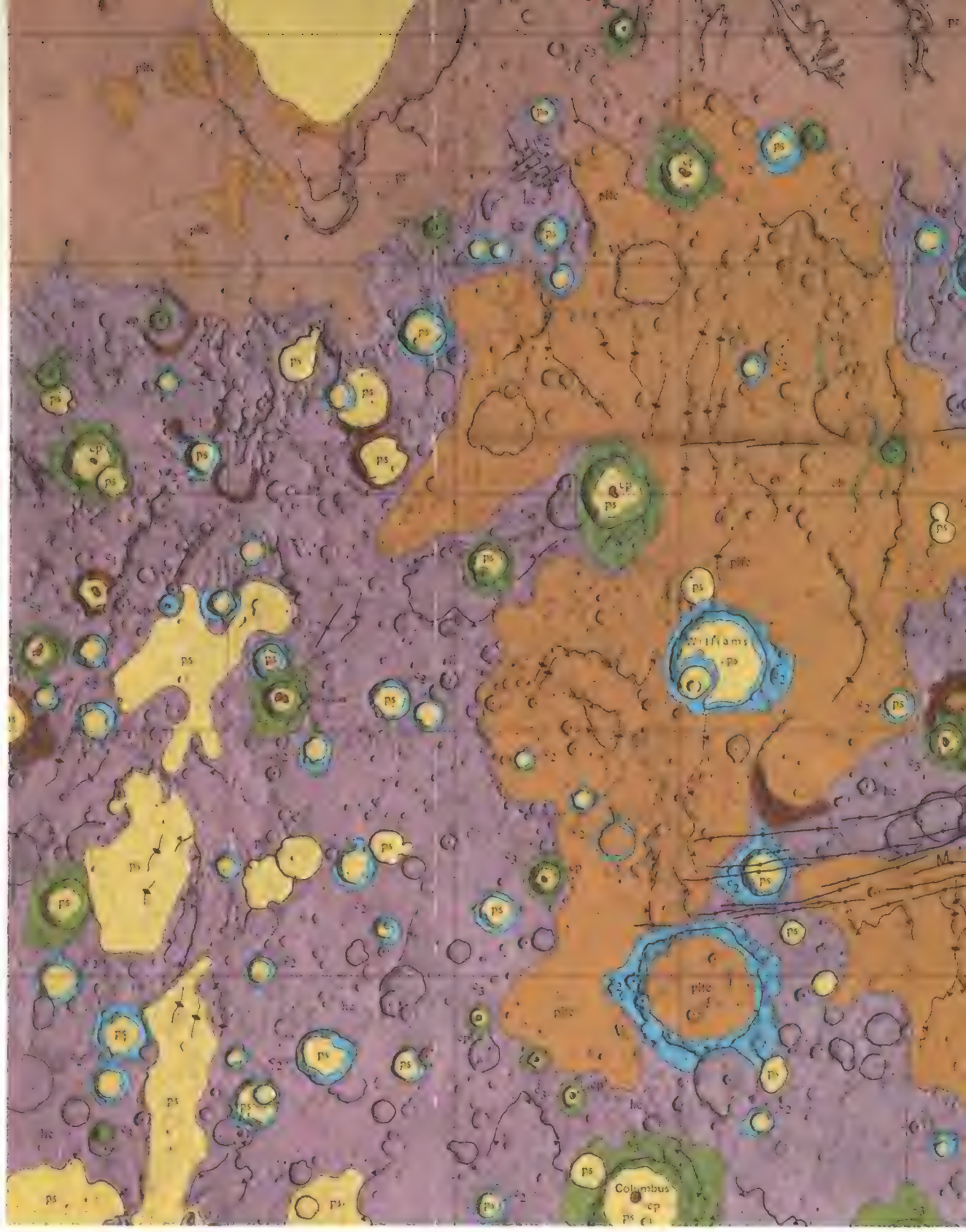
All 200 employees of the USGS astrogeology branch share a boundless fascination with the alien worlds to which their work takes them every day. Far from being a calm, quiet tracing of delicate manuscripts, Space Age cartography is often a frenetic job demanding the talents of geologists, cartographers, artists, and mathematicians. And their talents are called upon in the earliest stages of planning new exploration.

In preparation for a mapmaking job, USGS geologists help planetary mission scientists pick targets for spacecraft photography. Years later, when pictures are transmitted to Earth, the process of transferring data from the photos to a map begins in the Flagstaff center's photogrammetry division.

The photogrammetrists perform such tricky tasks as designating surface elevations on waterless planets with no sea level to serve as a base. Luckily, a planet's gravity field can be used to establish a value akin to sea level, says Sherman Wu, chief of the photogrammetry division. Pointing to a Martian gravitational map, Wu explains that a planet's center of gravity, determined by the planet's gravitational pull, can be used as a reference point for surface elevation measurements.

Easily recognizable landmarks such as volcanic peaks or large craters serve as control points. Wu's staff determines the longitude, latitude, and altitude of each of these. "They're like benchmarks used to make terrestrial maps," Wu says. A mapping tool called a stereo analytic plotter is used to determine the relative elevations of these control points. The plotter, which can be operated automatically or manually, traces lines of elevation onto transparencies of the planet being mapped to connect the control points and reveal the topography of the planet.

The photogrammetrists use computers to make a mosaic of the planet, superimposing many photos and "stretching" them to fit a mathematical model of the planet derived from data on its size, density, location, and motion. The computer also compensates for the angle from which the spacecraft took the pictures in the mosaic. The planetary



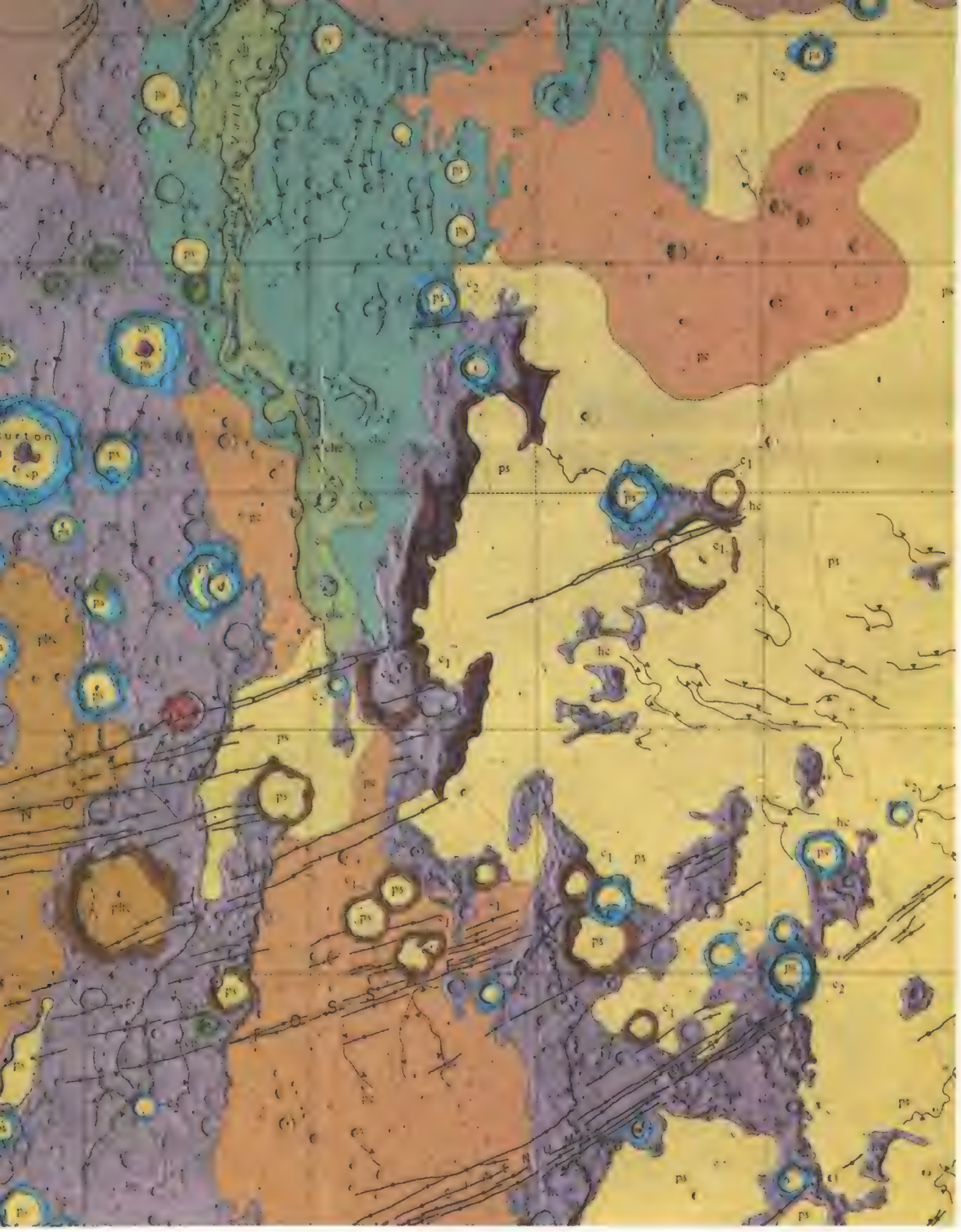
U.S. Geological Survey for NASA

cartography division uses these corrected photomosaics as mapmaking guides.

With the advent of increasingly detailed spacecraft imagery and computerized image enhancement, there would seem to be little need for artists in mapmaking. But human artistry is still needed to interpret photographs and work in revisions. "If there is one thing I've learned over the years, it's that photos only tell part of the truth," says Jay Inge, a cartographer in the planetary cartography section. Inge uses an airbrush and electric eraser to make detailed maps based on photomosaics.

Two pictures of the same area of a planet may differ in the amount of detail they reveal because of variations in illumination angles, data transmission quality, and geometric distortion. Inge and his colleagues study all available imagery of the area they're mapping, "getting an overall feel for the region," Inge says, and searching for areas on the photomosaic where they think detail is lacking. Their aim is to synthesize the best of what they see in the full set of pictures into a mental image of what the area really looks like. Too much detail can lead to confusion, Inge notes. Variations in soil color may resemble geologic structures, and "a dust storm may be important to one person and an obstruction to another."

Inge does his drawing on translucent matte-finish plastic, with a photomosaic laid beneath to establish the position of surface features. Drafts of the maps are sent out to scientists for comment. The planetary cartographers read the scientists' advice and decide what changes to make. From raw data to lithographic printing plate, producing a map can take as little as five days or as long as five years. The astrogeology branch com-



Geologic maps such as this one, which shows the heavily cratered Martian region named the Memnonia quadrangle, are used to study the aging of planets.

A mix of artistry and high tech, planetary mapmaking can be both tranquil and frantic.

pletes 75 to 100 maps per year, and the USGS usually prints 3,000 copies of each. Completed maps are shipped to a distribution center in Denver and the Planetary Data Facility in Flagstaff.

The Planetary Data Facility, jointly sponsored by the USGS and the National Aeronautics and Space Administration, sells the finished products and maintains a library of pictures and other data collected on U.S. missions throughout the solar system. On file here are 1.5 million pictures of Earth, the moon, and the planets and their moons, plus more than 500 maps of planets and planetary satellites. Scientists all over the world draw from this archive.

Another notable resource of the astrogeology branch is senior scientist Harold "Hal" Masursky. Visit mission control during any flight to a planet and Masursky will likely be in the thick of things, scrutinizing data or looking for landing sites. "He's an excellent committee person, a major figure in planetary programs," says Eugene Shoemaker, research geologist at the astrogeology branch and the man who hired Masursky more than 25 years ago. "He's probably better known to the Russians than anybody else in this field in the country." Soviet space experts have sought Masursky's advice on landing sites for a series of unmanned probes to Venus, and he frequently visits his Soviet counterparts at the Vernadsky Institute of Geochemistry, a rough equivalent of the Flagstaff center.

Finding the busy 64-year-old scientist requires an impromptu tour of the Flagstaff mapping complex, including a lobby crowded with a giant globe of Mars and dozens of large pictures of otherworldly surfaces. Corridors leading off the lobby are plastered with maps, photomosaics, tabulated data, and more planetary pictures—here the pocked red Martian plain called Argyre Planitia, there a print of a Soviet Vega probe's footpad on Venus. Offices are filled with the clutter of a score of projects—computer tape containers, maps, research papers.

Masursky can sometimes be found sitting at the end of a long table covered with stacks of reports in which he has an interest if not a hand. "I get a kick out of the nuts and bolts of missions—how to make a spacecraft work better, how to get more from a mission," he says with

The astrogeology branch is a haven for cartographers with artistic inclinations, like Jay Inge.

a grin, looking up from some Voyager imagery. "I also enjoy seeing pictures arrive for the first time from another planet. You know, I actually was more excited about the Viking orbiter pictures of Mars than those that came later from the Viking landers on the surface. The detail that appeared!"

In 1976, as NASA's pair of Viking orbiter-landers approached Mars and swung into orbit, mission controllers discovered that the planet was a lot rougher than they had expected. They delayed the descent of each frail lander while Masursky organized a search for safe landing sites. Masursky's inclination to tinker with spacecraft operations also helped to improve the definition of images from the Viking orbiters. Cameras on the orbiters were not designed to compensate for the planet's rotation, "so we actually moved the camera platforms," Masursky says, "and in some cases, we moved the entire spacecraft to get the highest resolution pictures."

Masursky came to Flagstaff in 1961, about a year after the astrogeology branch was established. Shoemaker and his crew had been handed the job of preparing the Apollo astronauts for their lunar landings, and the choice of Flagstaff as a home for the branch was not random. "This is one of the better telescope locations in the United States," Masursky explains. "It's also a volcanic area. It has Meteor Crater and a variety of geologic features that look like things we expected to find on the moon, such as big cinder fields with a lot of fragmented material."

Masursky's previous job as a USGS field geologist consisted mostly of mapping basalt flows and mineral deposits in the West. "It was a bit of a change," he recalls, "looking through the eyepiece of a telescope rather than walking in the field and pounding on rocks."

Masursky and his colleagues ran field trips that simulated lunar expeditions. "We set a landing module in the field and trained astronauts to look out the windows and locate their position by the topography," he says.

Fifteen years after the last Apollo landing and more than 10 years after the momentous Viking landings, Masursky is poring over Viking images of Mars, scouting out landing sites for an automated rover. NASA has proposed landing a rover on the red planet in the late 1990s that would pick up samples of rock and soil and return them to Earth. This project is not funded yet, but "I hope that we'll launch this mission while I'm still around," Masursky says. "We need to bring rocks back from Mars because we believe that Mars may still be geologically active." However, scientists can only narrow the time of this activity to within the past half-billion years or so. If Mars is still active, then giant volcanos such as Olympus Mons, which appear to be extinct, might be only dormant.

"We're finding very young stream channels and layered features—lava flows with craters overrunning older craters," Masursky says. Analyses of Martian rock and soil samples should reveal their ages. "If we just study the Earth," Masursky explains, "it's easy to draw the wrong conclusions. But if we see similar features on many planetary bodies, then we arrive at a more generalized understanding of the processes that formed the planets."

Reflecting on the work at the Flagstaff center, cartographer Jay Inge remarks, "People don't realize what an important time we live in. Things are happening that can never happen again. You can unwrap a planet only once; you can't discover it again. It loses some of its mystery forever."

That's not Hal Masursky's perspective, though. Peering through a magnifying glass at the details of a new computer-enhanced picture of Mars, he says with delight, "We're seeing tiny drainage channels we hadn't seen before in the Valles Marineris," a 2,500-mile-long canyon. It's not likely he'll lose his sense of wonder until every square inch of every planet has been sampled, walked, photographed, scrutinized, and, of course, mapped. ✦

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by U.S. Representative Norman Y. Mineta

Chairman, House Public Works and Transportation Committee's Subcommittee on Aviation

You've checked your bags, boarded the airplane, and settled into your seat. The attendants are bustling about preparing for takeoff. You have a few hours of flying ahead of you and a magazine to read, and you're looking forward to getting aloft so you can put your seat back and relax.

While you rummage through your briefcase, your flight is being processed through a complex system managed by the federal government, local agencies, and the airlines. This network has been created to ensure that your flight is handled safely from the time it leaves the gate until it arrives at its destination.

The flight crew works with air traffic controllers, who monitor and help direct the flights. Airport and airline employees prepare terminals and gate facilities for arrivals and departures. Baggage is sorted and processed. As long as this system runs smoothly, you need never question how the national air transportation system works, much less whether it works effectively. All you have to do is enjoy the ride and the view.

But when the pilot announces, "Ladies and gentlemen, I'm afraid we'll have to sit here for a while . . . ," doubt enters your mind. Why the delay? Maybe our air travel system is not as dependable as it should be.

The system is being squeezed. The record growth in the number of passengers has led to record numbers of flight delays and put pressure on people and facilities that threatens to reduce the margin of safety. Since

deregulation in 1978, the number of passengers has increased from 260 million to nearly 420 million last year. Passenger totals could reach 600 million by the mid-1990s.

Now we are suffering the adverse effects of this success. Passengers sit glumly as airplanes wait in long lines for takeoff clearance. Departing and arriving on time has become the exception rather than the rule. Baggage is lost or misrouted. Flights are canceled without explanation.

The increase in difficulties has one underlying cause: the aviation system has not expanded enough to handle the demand generated by deregulation. Airports such as Atlanta's Hartsfield and Chicago-O'Hare, "hubs" in the increasingly popular hub-and-spoke system, have to struggle to handle all the flights that use their gates. There are nearly 5,000 fewer air traffic controllers today than there were before the controllers' strike in 1981, and on average they are less experienced. And they must make do with outdated equipment—some of it 20 years behind the times.

If the air traffic control system is too busy to handle a flight, the airplane stays on the ground until it can take off, navigate to its destination, and land safely. Knowing that a delay is imposed to ensure safety doesn't make it any less irritating.

The solution is clear, and long overdue: we must upgrade our aviation system. More air traffic controllers must be hired, equipment must be updated, and airports must expand to accommodate more flights and passengers. Prodded by Congress, the Department of Transportation finally acknowledged the need for more controllers and last June asked for authorization to hire 580 more by September 1988. But the move came too late to dissuade current controllers from taking a step that dramatized their impatience with broken promises: last June, they voted to form a new union to replace the one disbanded after the strike.

As an air traveler, you are a partner in an agreement designed to ensure that the system has funds to keep up with the demand for increased service while maintaining safety. Every time you buy a ticket for a domestic flight, you pay an eight percent tax on the fare that goes into the Airport and Airway Trust Fund. Ticket holders for international flights pay a $3 surcharge. General aviation aircraft owners pay into the fund through a tax on fuel and aircraft registration fees. These taxes and fees can be spent only for improvements that will decrease delays and increase safety. Unfortunately, today $5.6 million in that fund remains uncommitted.

The trust fund was established as a response to the extraordinary growth of civil aviation during the 1960s. In 1970, Congress signed the Airport and Airway Development Act into law. Modeled after the Highway Trust Fund, it established a similar fund for the sole purpose of collecting user-fee revenues to be allocated for airport and air traffic control improvements. Recently, however, the gains made in airport capacity over the years were canceled out by the deregulation boom, and today the air traffic situation may be approaching the same sorry state it was in 20 years ago.

When federal budgeting works the way it should, trust fund money is available to help airports acquire land for runways and upgrade navigation and communication aids. These funds also support the modernization of the national air traffic control system's radars and computers. In addition, the funds can be tapped for research and development of new technologies, such as terminal Doppler radar to detect wind shear.

But the taxes, fees, and interest pouring into the trust fund at a rate of $3 billion per year are not being applied to problem-solving at the rate they should be. In the last five years, the amount of funds collected has exceeded expenditures by nearly $6 billion. The National Airspace System Plan, established to bring the air traffic control network up to date by the 1990s, is one of the victims of this sluggish spending: it has received only $4.8 billion of the $6.3 billion Congress authorized over the last five years.

The trust fund is flush with money because under the current budget system, it can be used to make the federal deficit look smaller—on paper. I'm as worried about the size of the deficit as anyone. But freezing up desperately needed money provided by users is not the way to reduce the deficit.

We can attack this dilemma by cutting the ties that bind the trust fund to the federal budget and appropriations process. We can remove the incentive to let the money sit while retaining federal oversight to ensure its responsible use. Aviation programs should be judged on their own merits, not on the illusory benefit of making the deficit appear smaller. And travelers should not be left on the tarmac while their taxes wait to be spent.

We have problems with our air transportation system, but we also have the money and the technology to solve them. What we need now is the will.

Travelers wait on the tarmac while their taxes wait to be spent.

High Gs, High Risk

The force is with you,
like it or not.

by Jay Stuller

Illustrations by Greg Harlin/ Stansbury, Ronsaville, Wood Inc.

A violent, invisible adversary lies in wait for fighter pilots. As F-16s and other fast, agile aircraft are whipping into turns at high speeds, the pilots are slamming into a monstrous force that can drain blood from their eyes and brains and leave them unconscious as their craft dive into the ground. About ten years ago the Air Force recognized this enemy's potential to kill, and since 1983 it has been training pilots to combat the mysterious power of sustained acceleration, or high Gs.

The "G" comes from gravity, "a strange, paradoxical force," says Ralph Pelligra, a physician at the National Aeronautics and Space Administration's Ames Research Center in California. Among its properties, explains Pelligra, who studies the effects of enhanced and nullified gravitational forces on human beings, is the power to make objects accelerate. This property explains the use of the symbol "G" as a unit of measurement expressing the magnitude of an acceleration.

In the absence of air resistance, a penny dropped from the top of the Empire State Building would fall 32 feet per second *faster* with each passing second than it had the second be-

fore—in other words, it would accelerate at the rate of 32 feet per second per second. This is the magnitude of acceleration produced by Earth's gravity and is expressed as 1 G.

In everyday life, we rarely experience rates of acceleration greater than 1 G. On an amusement park roller coaster, riders can feel a brief jolt of between 3 and 4 Gs. A race car driver might routinely experience half a G during turns. A shuttle launch puts its crew through 3 Gs, while Apollo astronauts atop the powerful Saturn V rocket pulled about 4.

The Apollo astronauts were experiencing *linear* acceleration, caused by a change in speed. Such a change, either an increase or decrease in speed, requires force and produces a reactive, or inertial, force. An acceleration force can be produced not only by a change in speed but also by a change in direction. This is *radial* acceleration, the kind most frequently encountered by fighter pilots. If an object turns or banks, an acceleration force is exerted toward the center of its circular path. The reactive force is generated outward from the center. This force is what a pilot experiences in an aircraft pulling out of a dive or executing a sharp turn.

Even in radial acceleration, speed is an important part of the G-force equation. When direction is changed at high speed, the magnitude of the acceleration force is greater than when direction is changed at a lower speed. The magnitude of the force is also directly proportional to the sharpness of the turn. A fast aircraft turning sharply creates an immense acceleration force, and both craft and pilot are subjected to the equally immense outward push of the reactive force.

To imagine the effects, try to remember when you swore you'd never get on a carnival ride again because you were slammed into the corner of the car, arms pinned back, head leaden and impossible to lift, a grin (or grimace) pressed on your face. Now multiply that feeling by ten. A touch of acceleration force is one of the kicks of braving a mean coaster, but the severe physiological effects of high Gs are among the dangers of flying high-performance aircraft.

In the simplest terms, high Gs act like a pressure or weight on the pilot's body. The pressure is usually exerted in a head-to-foot direction because of the pilot's orientation to the inertial force when the aircraft turns or pulls up. This pressure forces blood to pool in a pilot's legs and abdomen, denying vital oxygen to the eyes and brain. Vision loss from the effect is temporary and rarely serious. But the brain has only three to five seconds' worth of oxygen stored up; when the oxygen is depleted, anoxia occurs, a condition that shuts down all conscious control of the body as instantly as a light switch.

Pilots reported mild experiences with acceleration forces as early as World War I. They complained of blurred vision when pulling out of dives or executing severe combat maneuvers. By World War II, improvements in aircraft design resulted in increased G forces and more serious effects on pilots. Retired Admiral Edwin M. Wilson recalled some of the effects in an interview published in the naval air station magazine *The Carrier.* While flying Curtiss SB2C Helldivers in World War II, Wilson said, he expected to lose his vision on pullouts. Making a vertical dive from about 10,000 feet, Wilson would release his bomb at 2,000 feet, pull back on the stick and generate, if only momentarily, between 5 and 10 Gs.

"I would pull the stick back to my gut and would immediately black out," he explained. "It happened to every pilot and gunner in a pullout. The blood would leave my head. I could hear but I couldn't see. Yet I was always aware enough to keep the stick back until the pullout was complete."

But the airframe would not allow the Helldiver to sustain high Gs. "In older fighters," says Colonel Allen Boone, an air commander at the Fresno Air National Guard Base in California, "you don't have the thrust-to-weight ratio to get into a really high-G turn and stay there. For one thing, you have to be careful not to push the plane past its structural limits."

The apparent weight felt by a pilot in a high-G turn is also felt by the airplane. Every additional G increases the weight the wings must support, and if the wings are overloaded, they will break off. But usually before any structural damage can occur, air resistance will slow an airplane in a turn, which will cause the Gs to drop.

Pilots, too, can level off to reduce the Gs. "When you go from grayout [a form of tunnel vision that turns the sky on either side of the cockpit gray and fuzzy] to blackout [total loss of vision], the visual cues should tell you to ease off on the maneuver," says Boone.

But the remarkable power and agility of modern fighters, particularly the McDonnell Douglas F-15 and General Dynamics F-16, enable them to snap into high Gs almost instantly and maintain the load without risking structural integrity. In combat, explains Air Force pilot Greg Frazer, even a 1-G advantage over an adversary can be critical: "If all else is equal, that extra G means you can turn or maneuver better than the other guy, get on his tail, and shoot him before he shoots you. One G can win the war."

However, such forces, as the military has now learned, can also kill: pilots have crashed because of something called "G-induced loss of consciousness," or G-LOC. The F-16's computerized fly-by-wire controls include a "G inhibitor," which keeps the craft from maneuvers that exceed 9 Gs and therefore frees the pilot to jerk into a 9-G turn, knowing the airframe can take it. Such turns may bring on "very high onset Gs," forces that can simply dump the pilot into G-LOC.

"With very high onset Gs," explains Carter Alexander, a physician at the Air Force School of Aerospace Medicine, "the pilot goes almost instantaneously from total consciousness to unconsciousness, with no visual warnings like grayout and blackout." And once G-LOC occurs, he adds, "you don't recover in four or five seconds even if the load is removed. It takes a minimum of 30 seconds, and can take as long as a minute and a half, before cognitive function returns."

If the pilot is lucky, says Alexander, "he wakes up in parts of the sky where he didn't intend to drive." But when a pilot's lights go out, if only for a moment, in the midst of diving and looping combat maneuvers or at low altitudes, much worse things can happen.

According to the Air Force Inspection and Safety Center at California's Norton Air Force Base, a clearinghouse for information on all fatal Air Force mishaps, 10 crashes, involving several types of fighters, are confirmed G-LOC incidents. Sources at the center suggest that F-15s and F-16s make up the bulk of G-LOC crashes. However, a reading of military journals, such as *Flying Safety,* and aerospace medical textbooks makes clear that G-LOC—along with certain spatial

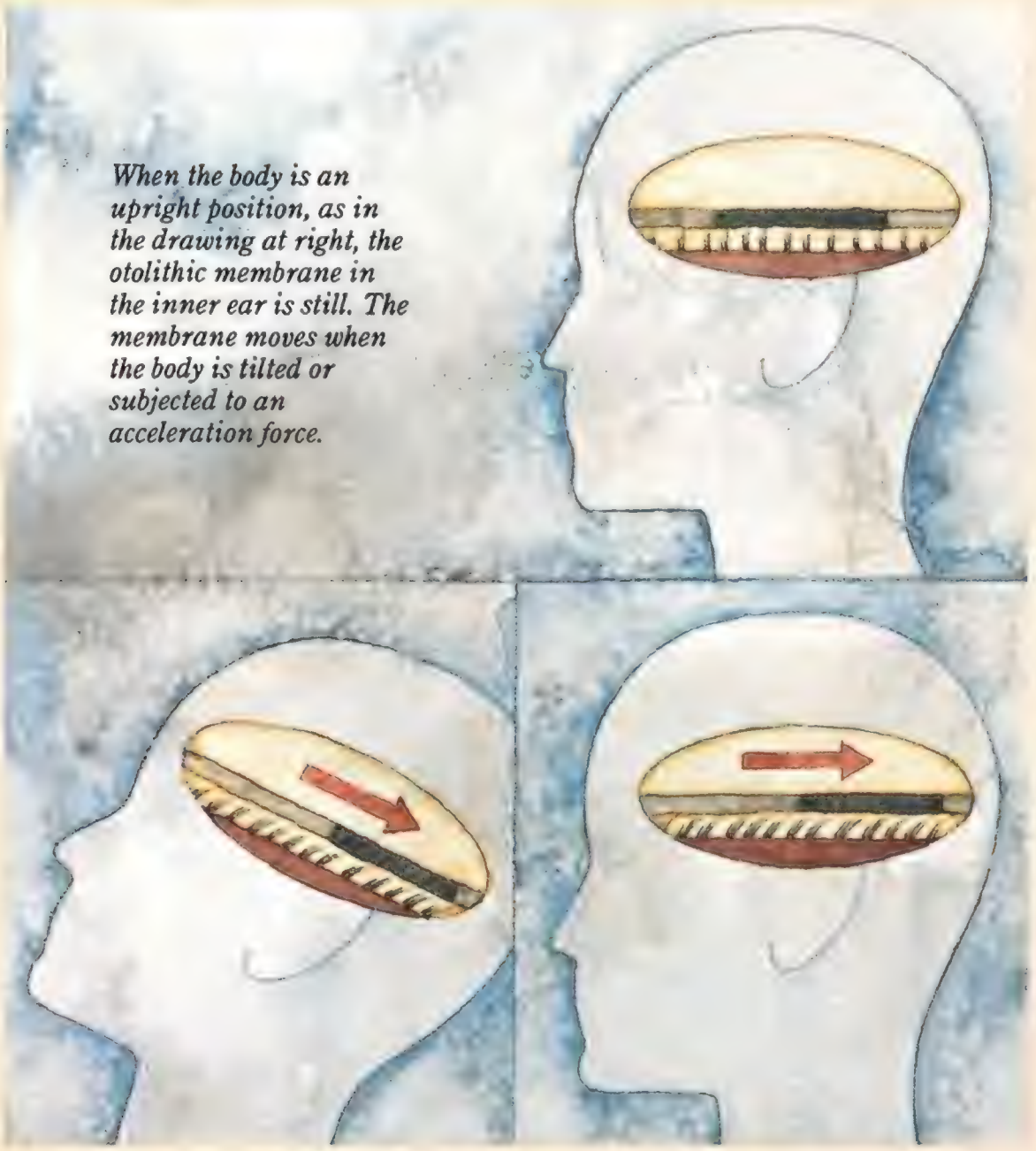
disorientation effects of G forces (see "Grave Illusions," below)—is a prime suspect in probably dozens of accidents.

Given the fact that anoxia is an unconscious state, pilots in craft that fortuitously level off are often only vaguely aware that time has passed, says Alexander, and can't be sure how they got in trouble. For those who remain asleep, G-LOC is a silent killer; frequently, safety investigators can only speculate that it's a cause.

A pair of incidents, tersely described in a 1983 *Flying Safety* story, seem to typify the problematic nature of G-LOC. While flying an A-10, according to the article, "pilot initiated 70 degree banked turn from downwind to deliver ordnance. Aircraft flew smoothly into the water with no transmission from pilot or attempt to eject." Following an A-7 bomb pass, "pilot made what appeared to be a normal wings level pull off [sic]. Aircraft impacted 4 miles beyond target with controls neutral and no call or ejection attempt."

The center of operations for the battle against G-LOC is the Air Force School of Aerospace Medicine at Brooks Air Force Base in Texas. Although the school is primarily a research and educational institution, the rise in G-LOC incidents forced it to assume a pilot training role. Alexander and the crew technology division at Brooks are working to prevent G-LOC-caused deaths by developing new types of equipment and, since 1983, by training pilots in techniques to keep themselves conscious.

Acceleration forces, explains Alexander, basically challenge the cardiovascular system by increasing the pressure against the column of blood traveling from the heart to the eyes and brain. The effect is like stretching the pilot's neck to giraffe length. "The heart has to work harder to move blood up the



When the body is an upright position, as in the drawing at right, the otolithic membrane in the inner ear is still. The membrane moves when the body is tilted or subjected to an acceleration force.

Grave Illusions

G-induced loss of consciousness, or G-LOC, is an abrupt phenomenon, hitting like a hammer. G forces more frequently create subtler, more insidious problems for aviators. Acceleration can confuse the otolith organs, small structures in the inner ear that communicate information about the body's position in space—upright, prone, or in between, for example—and therefore its orientation to Earth's gravitational pull.

The otolith organs are essentially gravity receptors. When the body or head is upright, the otolith organs sense the downward pull of gravity. When the body or head is tilted, the otolithic membranes inside the organs slide across the fields of cilia, or fine hairs, beneath them. This movement sends neural impulses to the brain, messages that convey the new direction from which gravity is pulling.

However, the membranes also move when subjected to acceleration forces. When a body changes speed or direction, the brain sometimes gets the message that the direction of gravitational pull has changed. This can lead to several kinds of spatial disorientation. Most quickly pass; others can wrap up pilots in a perceptual straitjacket.

For example, it is common on takeoff for pilots to perceive a nose-high attitude when the airplane is actually near level or at a mild angle of attack. The forward acceleration of takeoff, perhaps as low as 1 G, displaces the otolithic membranes toward the back of the head. But while the airplane is at a slight angle of attack, the membranes are in a position that tells the pilot's brain that the airplane has pitched up 45 degrees.

If a pilot who is unaware of the phenomenon has no visual clue to counteract the illusion, he is tempted to push the stick forward to level the airplane. This action would, of course, put the airplane into a dive. Carrier-launched pilots are particularly aware of this disorientation because they are subjected to an intense pulse of 3 to 5 Gs on takeoff.

Kent Gillingham, a physician at the Air Force School of Aerospace Medicine, says that the best way to prevent spatial disorientation is "instrument discipline." Pilots who develop the habit of frequently monitoring their instruments trust the information they receive from them. Pilots must also be aware that the information they receive from their own sensors, such as the otolith organs, require vastly different interpretations in an airplane.

—Jay Stuller

column, because the weight of the blood is increased by every multiple of G," says Alexander.

An unprepared or untrained subject could lose consciousness while pulling 5 Gs, but a pilot can help keep blood in his brain by performing two "grunt" maneuvers. Slowly and forcefully exhaling without letting air escape and tensing the muscles as if lifting a heavy weight help a pilot "almost double his G tolerance," claims Alexander. "If a pilot can resist 5 Gs, we can normally get 9 Gs out of him with straining."

Fighter pilots get additional help in countering G forces by wearing anti-G suits, which look like high-tech chaps and contain five bladders that inflate under acceleration forces. The bladders squeeze the legs and stomach to prevent blood pooling, thereby increasing resistance by one more G. The first practical anti-G suit, developed in the early 1940s by Canadian aeromedical researcher W.F. Franks, was a water-filled, double-layered rubber suit that used hydrostatic pressure to assist the veins and arteries in the abdomen and lower extremities. The U.S. Air Force developed the inflatable anti-G suit at about the same time with the help of corset manufacturers.

Certain biomechanical reactions, such as a heart rate increase, also help pilots resist unconsciousness, especially if the loads come on with a predictable and relatively slow buildup. In F-16s that's rarely the case, so pilots about to be trained to fly them are first sent to Brooks for high-G training in the school's centrifuge. The centrifuge, powered by four synchronized 500-horsepower motors, simulates the acceleration forces experienced in flight and can increase G loads at the startling rate of more than 6 per second.

"We'll take 'em from 1 to 9 Gs in two seconds," says Alexander, "or run them through profiles that simulate aerial combat maneuvers." Sometimes the centrifuge is controlled externally by an operator; at other times a pilot will "fly" the centrifuge with controls on the inside. In either case, the centrifuge tests are filmed, so physicians can work with pilots to improve straining techniques.

Pilots are prepared for centrifuge training by classroom lectures that explain what high Gs are about to do to their bodies. To impress upon trainees the seriousness of the forces at work, Alexander shows them a black-and-white filmstrip of an incident now famous in Air Force circles. About six or seven years ago, not long after the F-16 became operational, a student pilot and his instructor were going through combat maneuvers, serendipitously recorded on a cockpit camera.

The film shows the pilot pulling through a sharp 7-G turn, the sound capturing the grunts of his straining. But suddenly the grunting falls away, even as acceleration drops below 5 Gs. The pilot's head slumps and the airplane heads for the ground at Mach 1.

The instructor pilot, who had a reputation for unflappability, initially thought his student was maintaining control. He finally took over, saving the craft with a 9.3-G pullout and barely missing the ground.

It was later found that the student's anti-G suit hose had become disconnected, and the bladders had never inflated. Though he insisted he'd only grayed out, the filmstrip shows the pilot in dreamland for 17 seconds, and incapacitated for 21. "This film at least convinces pilots of the F-16's G-LOC potential," says Alexander.

Experienced pilots begin to compensate physiologically before going into a high-G maneuver. Fliers are constantly urged to "get on top of the Gs" and start straining maneuvers before the full force hits. In anticipation of the acceleration stress, the heart rate rises. Moreover, cardiac output increases under the physical stress of straining, boosting blood pressure to compensate for the G-induced drop.

"I always find it easier to withstand the Gs when I'm doing the flying," says pilot Greg Frazer. "When I'm in the back seat, I'm never really sure when we're going to hit it and am a little behind on the straining."

Pilots of high-performance craft are also advised to refrain from excessive aerobic conditioning; lower blood pressure and heart rate make them vulnerable to G-LOC. Instead, moderate aerobics and strength training are recommended.

It's also true, says Alexander, that frequent exposure to high-G loads builds tolerance, although repetitions of heavy Gs in any given day are extremely fatiguing. Pilots who spend only a few days away from the flight line are advised to tackle Gs with caution until resistance rebuilds.

Many high-G difficulties occur when jet drivers are "checking six" in a turn—looking back for bogeys. Contorting the body compromises straining maneuvers, says Kent Gillingham of the School of Aerospace Medicine. "It's also possible that the defensive position increases the heart-to-head hydrostatic column height." Moreover, given the weight of crash helmets, checking six can cause neck and shoulder muscle strains.

Although acceleration forces can push eyeballs back into their sockets and pull internal organs away from their attachments, they generally do not cause physiological damage. There is no evidence to suggest that repeated exposure to high Gs is harmful. However, pilots occasionally suffer from "high-G measles," ruptured skin capillaries on their buttocks, backs, feet, and ankles.

The nature of the body's reactions to G loads depends on the direction of the force. Pilots usually experience positive Gs from radial acceleration, a force running from head to foot. Linear acceleration forward also produces a positive load, with the forces running from front to back.

Far more harmful to pilots are negative Gs. The term "negative" also expresses an increased force but reflects a different orientation of the pilot and airplane. Instead of running in a head-to-foot direction, the acceleration forces are exerted in a foot-to-head or back-to-front direction, such as the force in deceleration.

"I kind of like positive Gs," says Frazer. "They feel good coming through your body. But I really hate negative Gs."

In negative Gs, too much blood can be forced into the head and brain and can break blood vessels in the eye. Even 3 or 4 negative Gs cause redout, a condition probably caused by congested blood vessels in the lower lid that makes the pilot literally see red.

Negative high Gs, which can also lead to confusion, vomiting, sore eyes, and a vicious headache, are extremely rare; fighter pilots can almost always avoid them. Although the Air Force has conducted some experimentation with negative Gs (see "Mr. G," p. 72), pilots are not subjected to them in training. According to NASA's Ralph Pelligra, "Negative Gs can be fatal because they can burst blood vessels in the brain."

The Big Squeeze

High Gs make the heart work harder to get blood to the brain. The effect, shown at upper right, is like stretching a pilot's neck, thereby increasing the distance the blood must flow. This distance can be decreased by positioning the pilot in a reclining seat, shown at lower right.

The elasticity of veins and arteries allows those in the legs and abdomen to become engorged with the blood forced downward. The counter-pressure of an anti-G suit helps force the blood upward.

Imagine swinging a water-filled balloon in a circular motion. The water would pool in the bottom of the elastic balloon. But a corset around the balloon, forcing it to hold its shape, would prevent the water from pooling. The anti-G suit, drawn at lower right, works in the same way. By filling with air, five bladders in the suit exert a counter-pressure on the blood in the legs and abdomen.

Body position in the aircraft is another factor under study that may help pilots better tolerate high Gs. As early as 1935, investigators at Berlin's Aeromedical Research Institute found that positioning a pilot so that acceleration forces traveled in a back-to-chest rather than head-to-foot direction improved G tolerance. Using a research glider with a bed on which the pilots lay prone, the Germans discovered that 8 to 9 Gs could be easily tolerated. (Oddly enough, the craft was easy to control, with forward and downward visibility excellent. Checking six, as one might guess, proved nearly impossible.)

"The guy who wrote the book that was turned into the movie *Firefox* knew what he was talking about," says Alexander. In it, a fictional Soviet fighter airplane, the Firefox, has a variable-geometry seat that increasingly reclines as the Gs load. This is, clearly, an idea of the future, but also of the past.

Prior to World War II, the Germans also experimented with tilt-back seats, one of which reclined the pilot into a supine position when acceleration reached 3 Gs. When the load declined, two springs pulled the seat upright. Further research by British and U.S. aeromedical scientists has proved conclusively that a supine position improves G tolerance.

Standard fighter seats today are generally reclined at a 15-degree angle. The F16 and the Swedish Air Force Drachen have 30-degree seats, but some pilots don't like the position, saying it restricts vision.

There's not much that can be done with the current generation of fighters, Alexander notes. "To really achieve good G tolerance, a seat should be able to go back 45 to 65 degrees, and today's fighters just aren't configured to accommodate such seats." Although no variable-geometry seats are in the works, they'll likely be needed in the 12- and 15-G fighters that are on the horizon. Moreover, says Robert E. van Patten, chief of the acceleration effects branch of Armstrong Aerospace Medical Research Laboratory in Ohio, "there are airplanes on the drawing boards that go up to 20 Gs."

Meanwhile, researchers are looking into other ways to help pilots resist G loads in the already formidable F-15 and F-16. Anti-G suits with valves that sense G loads sooner and inflate faster than existing models may provide an additional half-G of protection. "Assisted positive-pressure breathing," that is, forcing more air into the pilot's mask and using a counterpressure device that pushes against the chest, also boosts G tolerance.

Until these improvements are perfected, pilots will still occasionally lose consciousness. For that reason Lear Siegler Inc., the company that builds the F-16's flight control computer, has designed an "auto-save" system. If the pilot goes into G-LOC and releases the stick, the computer will put the plane into a supposedly safe climb. Jet drivers, an independent lot, don't like that one either.

The Air Force is currently building a new training centrifuge at Holloman Air Force Base near Alamagordo, New Mexico, to help prepare pilots for the inherently hostile world of a fighter jet's cockpit. Alexander speculates that once the new centrifuge is ready, student pilots will take training rides for G tolerance before they fly. And biomedical engineers will continue striving to keep pace with aerospace engineers, who, according to Colonel Allen Boone, "are finally producing aircraft that can pull more Gs than the pilots who fly them."

Mr. G

Several technicians hovered around the man strapped into the padded metal chair, making last-minute adjustments in the restraining belts around his shoulders, waist, and legs. His hands were tied between his knees with webbing. A crash helmet with a plastic faceplate was on his head, and the helmet was also strapped to the headrest. Air Force colonel John Paul Stapp was about to be hurled along a 3,500-foot track on a sled powered by nine rockets with a combined thrust of 40,500 pounds. The rocket sled, built by Northrop Corporation in 1953, was called the *Sonic Wind I.* It would earn Stapp the title of fastest man on earth.

Stapp, who celebrated his 77th birthday last July, is still proud of the title and still remembers the final minutes of countdown on December 10, 1954, the day he earned it. He says he was just following orders. Then chief of the Aeromedical Field Laboratory at Holloman Air Force Base in New Mexico, Stapp was put in charge of a project to find the limits of human tolerance to linear deceleration and windblast. The Air Force needed to determine whether pilots could withstand such forces in emergency ejections from new high-performance aircraft, such as the F-101. Stapp volunteered himself as the subject in most of the experiments.

This was Stapp's 29th ride on a rocket sled. He waited out the final minutes of the countdown alone. "I was strapped in and waiting for about an hour and a half," Stapp recalls. "It was as if I were waiting for a firing squad." He was totally immobilized so that the terrific windblast he was about to feel (later calculated to be more than 1,100 pounds per square foot) could not whip his limbs, break his bones, or knock out his teeth. Other than the helmet and a protective rubber block in his mouth, Stapp wore no special protective clothing, just blue wool coveralls.

He thought about earlier, less powerful rocket rides, when he had suffered cracked ribs, broken wrists, a broken tailbone, and retinal hemorrhages. How much pain would there be this time?

Sixty seconds to go. The end of the countdown was always stressful—an interminable wait for a bone-wrenching ride that would last less than 6.5 seconds. His pulse quickened and his blood pressure rose. At the far end of the track the ambulance and flight surgeon were waiting.

The last seconds had the emotional weight of years:

Four . . . three . . . two . . . one . . .

A tremendous jolt rammed Stapp in the back, and his body was subjected to a force

19 times stronger than gravity in less than 1/14 of a second. It felt as if the sled were climbing steeply up the flat tracks, but it blasted straight ahead. During the first fraction of a second, he saw the ditch between the steel rails blur. After 1.5 seconds he could see nothing; the 19 Gs of force against his body drained all his blood, including that in his retinas, toward his back. In just 5 seconds, the rockets blasted the sled 2,800 feet to a top speed of 632 mph, just under of the speed of sound. In that instant, Stapp became the fastest human on the face of the earth. Literally faster than a speeding bullet, Stapp on his sled pulled ahead of a T-33 chase plane flying overhead.

But the most painful part was yet to come: the effects of deceleration forces, which the experiment was intended to measure.

A slight reprieve at the instant of rocket burnout lasted about 0.2 second as the *Sonic Wind I* decelerated in the air drag, building up about 19 Gs of reverse force. That brought the blood back to his retinas. In that instant he saw light again, first a bright yellow, then a brilliant flash. He saw the first explosive splash as the scoop-like brakes under the sled grabbed into the water at the end of the track. Then, as blood burst forward into his retinas, everything went red.

Stapp and his sled came to a dead stop in 1.4 seconds.

"It felt as though my eyes were being pulled out of my head," Stapp says. "My eyeballs pushed against the upper lids, tugging at their attachments with a searing pain like a dental extraction without anesthetic. Vision flashed through yellow to a salmon-colored blur as the pain mounted to an almost unbearable crescendo."

The flight surgeon ran to the sled. Stapp's face was scarlet. Then it turned blue as he fought for air. The doctor quickly pulled out the bite block and cut away the chest straps so that Stapp could breathe normally.

His eyes were filled with blood, and tiny hemorrhages could be seen in the skin around his eyelids and nose. His shoulders were covered with small blood blisters, caused by specks of sand blasting into his flesh.

"I lifted my eyelids with my fingers, but I couldn't see a thing," Stapp recalls.

The rest of the crew lifted Stapp onto a stretcher. After a minute or two, he saw some tiny blue patches, and within eight minutes he saw one of the doctors wiggle his fingers at him. Until that moment, he had been picturing himself with a white cane and guide dog.

"I could see," he says, "but I was having double vision because the muscles around the eyeballs were swollen and the eyeballs didn't track together."

As the ambulance rushed him to the hospital, Stapp experienced intense euphoria. He was giddy with the realization that he was alive.

After staying in the hospital three days for observation, Stapp was released with two black eyes. During that time, the Air Force doctor had become a hero. His story was told around the world, and his portrait appeared on the cover of *Time* magazine. He appeared on Ralph Edwards' "This Is Your Life." Later Stapp was portrayed in the Twentieth Century Fox classic motion picture *Threshold of Space*. Much of the media coverage missed the main point of Stapp's daring feat: he had risked his life to save the lives of pilots.

Stapp's historic rocket sled ride was only one of dozens of tests conducted over the years, both at Holloman and at Edwards (then Muroc) Air Force Base, that produced a large database on the human response to high-G and windblast forces. These experiments put to rest the theory held by some scientists that the human body could endure no more than 18 times the force of gravity. During the deceleration of his December 10 run, Stapp experienced an average of 27 Gs for 1.1 seconds and more than 40 Gs for 0.25 second. The 27 Gs that Stapp experienced, a report later stated, "far exceeded any predicted G time patterns for high speed aircraft ejections." It was later calculated that the deceleration forces were equivalent to an open-seat ejection from an aircraft flying 1,800 mph at 36,000 feet.

On the basis of the Holloman and Edwards tests, the Air Force eventually modified seats, helmets, arm and leg supports, and safety harnesses to improve protection. And out of the same large database came information that would lead to car seat belts and many other transportation safety features available today. Stapp pursued work on transportation safety at the U.S. Department of Transportation in the 1960s.

His historic rocket sled ride was the last test the Air Force allowed with a human subject. Stapp believes the human tests were stopped because of an incident that occurred the following month. During an unmanned test run, the sled was rocketing along at 640 mph when one of the steel slippers holding it to the track failed. The sled flew off the track and tumbled across the New Mexico desert for a third of a mile.

But in Stapp's 23 years of research, which involved more than 5,000 tests on all types of equipment, there was not a single fatality or disabling injury.

"Every one of these tests was a known hazard," Stapp says, "because that was what we were exploring—hazards of flight. I am extremely proud of this record. In this business, you don't worry about your hat. You just try to hold onto your head."

—Neil McAleer

Cake, Ice Cream, and Classifieds

Trade-A-Plane celebrates 50 years of yellow pages.

by Lorraine Norwood

Photographs by Will and Deni McIntyre

It offers no editorials, advice columns, or comics. Its classified ads, in tiny black type on canary-yellow paper, can result in green-tinged vision after an hour's reading. But substance, not style, has made *Trade-A-Plane* required reading for pilots since 1937.

Trade-A-Plane is a shopping guide to hundreds of used airplanes, parts, jobs, equipment, and services. One issue—which can have as many as 175 pages—is a week's worth of reading, particularly if you read between the lines: there is a wistful tone to an ad for a 1938 Piper Cub, youthful enthusiasm in the Positions Wanted column, and the scent of new leather in the corporate jet ads.

Trade-A-Plane has brought together more than just airplane buyers and sellers. It has wrapped up all things aeronautical in a bright yellow package and delivered it to general-aviation enthusiasts en masse. Though the majority of *Trade-A-Plane* subscribers live in the United States, home of most of the world's used aircraft, it is also read in Canada, Australia, Europe, Africa, and South America. Published in Crossville, Tennessee, three times each month, the paper has a worldwide circulation of more than 70,000.

COMMERCIAL AIRPORT, 10 mi. N. of Escanaba, Mich. 3,100-ft. sod strip, 10,000-gal. fuel farm. Modern 2–3 bdrm. home, attached 2-car garage, barn w/lean-to hangar, 12-ft. satellite dish, apple trees. Beautifully landscaped. Unlimited potential. By owner, $175,000.

But to imply that *Trade-A-Plane* is simply an aviation buyer's guide is like saying the Wrights were just test pilots. In its ads one can trace the history of flight. The reverence with which aviation devotees regard *Trade-A-Plane* is akin to that of a gardener getting the first seed catalog of the season. Subscribers enter a fantasyland when they open each issue. Some simply dream of owning their first airplane; others dream of a bigger, better, older, or newer one. One reader, an aircraft broker in Switzerland, values his copies so highly he stores them in a vault every night. And three years ago a Massachusetts couple left their children with grandparents and drove a thousand miles to Crossville, just to get a jump on the latest issue. *Trade-A-Plane* in hand, they turned around and drove home.

FOR SALE OR LEASE: DC-3, class recognition for company or product. A Goodyear blimp that goes 200 mph. Wings are billboards. Fantastic smoke system, air conditioning, bar, TV, 15 comfy seats.

For at least one reader, *Trade-A-Plane* has redeeming social value. "I find myself reading garbage," he recently wrote, "when I should be reading something wholesome and American like Trade-A-Plane. I may never be able

From its plant in Crossville, Tennessee, Trade-A-Plane *helps makes the aviation world go 'round (above).*

Trade-A-Plane *went yellow during World War II to save money. It kept the color for the sake of tradition, even though white is cheaper today.*

Three generations, led by Mother Harrison and son-in-law Roy Stone (center), manage a thriving family business.

to afford the items offered in your periodical, but it keeps me off the street and also keeps me from buying periodicals from places that Crossville residents would not be caught dead in."

Its following has elevated the publication to near-legendary status. But ask staffers about the *Trade-A-Plane* magic and they look bewildered. The company doesn't even own an airplane. When its sales people need to fly, they lease—everything from a Cessna 180 to a Citation business jet. Only one of the 90 employees has a pilot's license. Their biggest thrill comes from watching the new Swedish offset press print 25,000 copies an hour. And the formula that blessed *Trade-A-Plane* with success has also worked for a sister periodical, *Rock & Dirt,* published since 1950 for buyers and sellers of construction equipment.

It's a far cry from the single page of ads that Cosby Harrison first mailed to pilots on October 5, 1937. Harrison, a Cumberland County pool-shooting, poker-playing jack-of-all-trades, was 27 when Lindbergh flew to Paris, and the feat fired his imagination. After running a car dealership and garage, a movie house, and a meat market, he borrowed enough money to buy a 1929 open-cockpit Swallow biplane and learned to fly.

Several years later, on a muggy summer day, Harrison and a hefty passenger found that the Swallow, with its sluggish OX-5 engine, could not top the 3,000-foot Crab Orchard mountains between Knoxville and Crossville. Harrison decided to squeeze between them.

After nearly flying into a railroad trestle and a river, he gave up, settling into a field on the Harriman Ridge and crunching both the airplane and his pride. When he ran into trouble locating replacement parts, Harrison figured other pilots were probably having the same

MULTI-ENGINE SEAPLANE PILOT, 32, 6′, blond, well-educated, seeks intelligent, respectable SWF 22-34 obsessed with flying and the outdoors. I live in the Midwest, California, Germany, and the airplane.

EXECUTIVE BOEING 727: hush kits, forward & rear airstair doors, color radar, Flitefone, 28-passenger capacity, mid-cabin galley. Excellent maintenance by Eastern Airlines.

FORMER FAA 60-FT. CONTROL TOWER. Excellent condition, office, lavatory, kitchen, Otis elevator, standby batteries w/generator. Can be readily disassembled.

problem. He bought a list of pilots and aircraft owners for $25 to tap into the aviation grapevine, then put together a list of used airplanes and parts. "If an ad here does not get results," he announced in the first issue, "either your price is too high or presently no one is interested in what you are offering."

MANU'A AIR TRANSPORT INC. in Pago Pago, American Samoa, looking for airframe & powerplant mechanic with 3 years' experience in piston-power aircraft.

Harrison and his wife Margaret published *Trade-A-Plane* from their living room for a year. By 1938 they were breaking even, and the enterprise moved to Harrison's auto repair shop and then to a building behind the Crossville post office. Over the years the Harrisons began building a staff as well as a following. At the end of World War II, Cosby ran into Roy Stone, a former Crossville grammar school principal just out of the infantry, and offered him a job. Stone accepted, and the following year he married one of the boss' daughters, Joanne. By 1948 TAP Publishing Company was putting out three issues a month with a press run of 8,000 copies an issue, and had moved to a block-long building of Crab Orchard sandstone near the center of town.

Today, Margaret—"Mother Harrison" to employees—is 84 and oversees operations. After nearly 40 years as a homemaker, she took over *Trade-A-Plane* in 1961, after Cosby Harrison left her and the company to play the stock market and develop the Cumberland Valley's industrial and resort potential. The divorce shook the entire staff. Mother Harrison's first move as a publishing executive was to assure them that the company would not crumble. She's been at her desk five days a week ever since.

1948 HAWKER SEA FURY: Want to race at Reno? Lots of love and care went into 1981 rebuild and continued by present owner, Russ Francis of San Francisco 49ers. Priced to sell at $275,000.

When Cosby left, Stone was named publisher. He says a more accurate job title would be personnel manager. *Trade-A-Plane* is a family business, run by first-, second-, and third-generation partners and their spouses, and, like every family business, gets an occasional case of ruffled feathers. It's part of Stone's job to resolve personality conflicts among the three Harrison daughters and seven grandchildren who are working partners at the company.

WANTED: BEECHCRAFT BARON 58, trade $44,000 equity in Palm Springs, California townhouse, 2 bedrooms, 2 baths, pool, spa, tennis. $130,000 value.

When *Trade-A-Plane* first opened for business, Crossville's major industries were sandstone quarrying, potato farming, and manufacturing hickory handles for garden tools and golf clubs. It's still a small town that kicks off the United Way campaign with a cookout on the courthouse lawn, but it's also one of the fastest growing cities in Tennessee. In Rand McNally's 1983 *Places Rated Retirement Guide,* Crossville was rated number 4 out of 107 U.S. cities. It has its salad bars and BMWs, an exercise equipment factory, and a new $15 million ceramic tile plant. The quarries still churn out sandstone, but green beans have replaced potatoes as the main crop. The area's prime moneymaker is the resort industry, a legacy of Cosby Harrison, who died in 1984.

Harrison's aviation legacy, *Trade-A-Plane,* has been inherited by a loyal tribe that has no intention of tinkering with its unique style. They've added color photos on the cover and updated the logo, but the basic premise remains the same. Stone observes the rule for continued success: if it ain't broke, don't fix it. Nor are there plans to change the distinctive yellow paper, used since World War II, when shortages made it the least expensive medium. Stone says there was idle talk of changing to white—"It would be a lot cheaper for us now"—but advertisers shuddered at the thought of breaking with tradition.

"We offer a tool for the aviation industry," Stone says. "We don't use editorials and we don't push legislation. But if you want to buy or sell something, by God, we'll do it."

Of 90 employees, only Cosby Stone (far right), pilot and a grandson of company founder Cosby Harrison, jumps at a chance to fly.

FORWARD HALF OF A BOEING B-52 for sale, formerly used for motion pictures. Perfect for simulator. $12,000.

The Volvo 740 is built and engineered to withstand the kind of scrutiny one would expect from a person who has learned a thing or two about value.

In fact, no car is built to be looked at more carefully.

Which explains why so many people who look at other European imports end up with a Volvo in front of their house.

VOLVO

A car you can believe in.

THE SECOND LARGEST PURCHASE OF YOUR LIFE SHOULD BE AS CAREFULLY CHOSEN AS YOUR FIRST.

by Tom Huntington

Photographs by Medford Taylor

On an aircraft carrier, he's lord of the fliers.

THE BOSS

The aircraft carrier *Coral Sea* cruises off the Florida coast. Up in Primary Flight Control, a steel-and-glass blister that juts from the ship's towering island, someone spots an A-3 "Whale" in the distance. The old twin-jet's nickname is not an affectionate one. Big, heavy, and slow, the former bomber, now converted to carry electronic countermeasure equipment, has few fans here.

As the carrier turns into the wind so the A-3 can land, the shadow of the ship's superstructure pivots slowly around the flight deck. An SH-3H "plane guard" helicopter maintains a

Day or night, you'll find air boss Pete Peterson (above) on the horn in Pri-Fly, a windowed cab high over the carrier's deck. Or just mess up, and he'll find you.

Status board writers major in mirror-writing. Data on arriving aircraft are read from the other side.

An F/A-18, its tailhook set to grab a wire, approaches the air boss' vaporous domain—the deck and its entire crew.

slow orbit nearby, waiting to rescue any pilot unlucky enough to ride 60 feet from the flight deck to the Atlantic. It doesn't happen often, but it happens.

In Primary Flight Control—"Pri-Fly"—the petty officer at the arresting gear board verifies that the energy-absorbing engines attached to the four steel cables stretched across the deck are set to handle the weight of an A-3. The Pri-Fly lens operator double-checks the angle of an optical system that produces a beam of light to guide the pilot down to the deck. The status-board writer plots the impending arrivals with a grease pencil. He writes the information in reverse on his side of a transparent board so the air boss on the other side can read it.

The air boss is Commander Robert "Pete" Peterson. Almost never addressed by his official but less descriptive title, air officer, he is in charge of Pri-Fly and has ultimate responsibility for the safety of the aircraft coming aboard the *Coral Sea.* Tall and lean, the 19-year Navy veteran is dressed in the traditional yellow jersey with AIRBOSS stenciled on its front and back. He puts on his sunglasses to watch for the Whale, and recalling a line from the movie *Airplane,* jokes, "Guess I picked the wrong day to give up sniffing glue." Flight operations haven't started yet, and he's in a good mood.

Next to Peterson sits the assistant air officer, Commander John "Jack" Jones. He wears a yellow jersey that says MINIBOSS. As he waits, he works on a crossword puzzle. Peterson glances over. "So you're one of the guys who does those things in pencil," he says.

Now the A-3 is approaching for its first practice landing. The landing signal officer (LSO), who stands on a platform at the stern and talks directly to the pilots, doesn't like the Whale's approach and waves it off. The Whale pulls up into a climb and circles back for another try. This is hardly Peterson's idea of the way to start the day. The next touch-and-go is a good one, but after the pilot's third approach, the boss grabs his phone to the LSO. "I want him on the centerline!" he snaps.

Its practice approaches complete, the A-3 circles around to prepare for a full-stop landing. Now the arresting hook dangles from its tail at an awkward angle, like a broken stinger. Pilots try to snag the third wire from the stern, with advice from the LSO and guidance from the light system. There is very little room for error. Extreme cases may even require rigging the emergency barricade, a net that can catch an airplane that can't catch the wires.

The A-3 hits the deck again but "bolters"—the hook misses all four cables and scrapes uselessly down the deck, throwing off sparks. The Whale climbs away for another try.

Tension begins to build in Pri-Fly. More airplanes are on the way, and the Whale was supposed to be finished by now. First an A-6 Intruder thumps onto the deck for a fast touch-and-go, then it's the Whale's turn again. When it touches down, the hook grabs a cable, but the airplane lands flat and bounces several feet back into the air, listing precariously before being dragged to a stop near the end of the angled flight deck. Peterson leans over to the miniboss. "Did that make your heart go pitter-pat, Jack?"

From his perch in Pri-Fly, Peterson watches dozens of men scurry about on deck, all of them wearing life vests and helmet-like "cranials" with goggles and ear protectors. The colors of their jerseys and matching life vests indicate their duties. Green shirts operate the steam-powered catapults. Fire and rescue teams wearing metallic flame-resistant suits sit in fire engines resembling overgrown golf carts. Nearby, a red-shirted crash crew is alert for any mis-

hap. The instant an airplane stops, blue-shirted men dash beneath it, chock its wheels, and chain it to the deck. Purple shirts take care of fuel; yellow shirts direct taxiing aircraft.

The catapult officer wears a yellow life vest, goggles, helmet, and a radio headset called a mouse for its resemblance to rodent ears. The cat officer oversees the preparations for a launch, and when all is ready, he exchanges salutes with the pilot. Hand signals from the rest of the catapult crew confirm that the launch can proceed. He kneels, stretching out with one leg behind him, and points toward the bow in the traditional signal to launch aircraft.

A crewman at a console at the edge of the deck pushes a button, and the catapult whips the aircraft down the deck, excess steam belching from its shuttle as it races along the track. A slam jars the entire ship. Jet exhaust tickles the necks of the deck crew as the airplane roars past. Another airplane taxis into position, and the process begins again.

As the catapults launch airplanes, other airplanes keep landing—falling out of the sky is more like it—on the angled deck, to be "trapped" by the arresting gear. After coming to a stop, each airplane rolls back until the cable slackens enough to fall from the tailhook; the pilot looks for the nearest yellow shirt to guide him to his assigned place on the deck behind the foul line. If so much as a wingtip protrudes beyond this line, the deck is fouled—a "red deck"—and nothing can land until it's been cleared.

Lieutenant Commander Rob Madson, one of the *Coral Sea*'s catapult and arresting gear officers, is usually on deck directing the bow catapults, but at the moment he's taking time between operations to watch the activity on deck from the sanctuary of Pri-Fly. "Everybody is doing his own particular job," he says, "and it has to be coordinated with all the other guys. So many things are going on at once that the only way you can really grasp the whole ball of wax is to stand up here and watch it." The quiet up in Pri-Fly can create a deceptively casual atmosphere—the yellow jerseys and docksider shoes contribute to that—but the business here is deadly

"Miniboss" John Jones (with headset) can veto launches with the touch of a button.

When the cat officer points, a lunging A-7 gets a steam-powered boot.

serious. Banter may punctuate the conversation, but it never takes over. The source of final authority is never in question. The mood and rhythm respond to one man—the boss.

Air bosses are almost always former pilots, which adds weight to their authority over both aviators and deck crew. They know what they're talking about, they know what's possible, they know what to expect. Peterson flew E-2C Hawkeyes—big turboprop twins with radar antennas atop their fuselages—and was one of the squadron commanding officers on the *Coral Sea* before moving to the tower. As head of the air department, the boss has several hundred men under his control, about equal to the entire crew of a smaller ship, like a destroyer. Says Peterson, "The flight deck and hangar deck are my acreage: three catapults, five sets of arresting gear engines, including the barricade engine, the entire ship's aviation fuel system and all its assorted pip-

ing, pilot landing-aids television, which photographs all landings and takeoffs, the meatball [optical system], the LSO platform—all that equipment and all the people who operate it work for me."

The responsibility adds up to the one thing the boss can expect from his job: long hours. Peterson says, "Last cruise, I don't know how many days on end I worked 20 hours on and 4 off. We were off the northern coast of Libya and I slept up here on occasion. We've got a little cot that folds into the wall back there. I ate probably two out of three meals a day up here."

The job sounds like a coffee achiever's dream, but Pri-Fly can become a little too crowded. "You get claustrophobic," Peterson says. "Actually, I

guess there's a point when you just get too tired to leave. You're just glad for the hectic environment to die down long enough so you can just sit down and relax and hopefully catch a wink."

This week the *Coral Sea*'s mission is carrier qualifications (CQs)—practice landings. On a normal cruise the hangar and deck would be packed with aircraft, but now the airplanes are shuttling back and forth from bases on shore, and the cavernous hangar deck is empty. On the flight deck, only a few sleek F/A-18 Hornets sit just aft of the Pri-Fly island.

Already there's a problem. A helicopter scheduled to arrive from shore has not reported in, and Peterson has to decide whether to wait for it. He decides to start operations, but the missing chopper has not helped his mood.

He grabs the microphone for the public address system. "On deck! Time for all personnel to shift into proper flight deck uniform. Helmets on and buckled. Goggles down. Sleeves rolled down. Life vests on and securely fastened. Search pockets and pouches for loose gear or check for FOD about deck. Stand clear of intakes, exhausts. APUs, start the fighters. Start 'em up."

The three F/A-18s behind the island start their engines, then taxi to the bow cats. Water-cooled blast deflectors rise from the deck behind them, and the cat crews swarm about, preparing the airplanes for launch. The pilots check their controls, and the waggling control surfaces give the F/A-18s the air of cats flicking their tails before they pounce.

The miniboss watches the launches closely, his fingers poised over two buttons on the console in front of him. He can use them to prevent a catapult from being fired if something goes wrong. But the F/A-18s are launched without incident. The cats accelerate them to flying speed in three seconds, and as they are released into the air, condensation trails from their wingtips like streams of ghostly ectoplasm.

The boss and miniboss talk constantly on various phones and microphones. They are linked to the Carrier Air Traffic Control Center (CATCC), the radar room inside the ship where aircraft are tracked. They can also talk with the LSO, the catapult officer, and the air-

Peterson's authority doesn't emanate from the label on his shirt (right). Like most air bosses, he is a former pilot, so his is the voice of experience.

craft handler on deck. Sometimes they talk on two phones at once. "Usually when you're on two phones the captain calls," Peterson says, "and then you've got three phones with the cords all tied together."

Pri-Fly's radios crackle with many voices and a peculiar vocabulary. The "meatball," or just "ball," is the light at the center of the optical system that guides the pilot to the deck. An LSO

The otherworldly atmosphere in the carrier's air traffic control center contrasts with the din on deck.

reminds a pilot to "call the ball"—report the meatball in sight and announce the amount of fuel remaining; his "fuel state" will dictate where he goes on the deck once he's landed. If he has plenty of fuel, the boss may tell the aircraft handler to "shoot the ball"—send the airplane right back to the cat for another launch. Or the boss may decide to "stuff the ball," to put the airplane out of the way and shut it down. If the flight has reached "bingo," the minimum fuel required to make it back to shore, the Boss tells the handler to "pump the ball," meaning fuel the aircraft.

People talk about traps and cats, or decide that a pilot's approach is AFU—all fouled up, or words to that effect. There is talk of CODs, carrier onboard delivery airplanes that bring mail, visitors, and other surprises from shore. The VOD—vertical onboard delivery—is a helicopter that performs the same job. FOD is foreign object damage, the curse of a flight deck, where any object sucked into a jet engine can damage or even destroy it. Several times a day the crew performs a FOD walkdown, patrolling the deck to make sure it's clean.

"We're going to have to pump the Whale after his next trap," the air boss phones the aircraft handler, who holds court in a tiny cramped room in the base of the island. Commander James "Hose" Turner, a stocky, mustached man, is doing his first tour as handler after working on the catapult maintenance crew.

He and his men sit around their "ouija board," a plexiglass table marked with a schematic of the carrier's flight and hangar decks. On instructions from Pri-Fly, Turner's people move plastic airplane cutouts around the board. The color of a nut placed on a cutout indicates whether the airplane needs refueling, maintenance, or some other service. One of the greatest fears is not being able to land airplanes already in the air. "If Air Ops puts on too many planes, I have the obligation not to launch them," Turner says. And he'll voice his veto at the daily air plan meeting, where goals are set.

Over the radio in Pri-Fly, CATCC is heard advising an F/A-18 pilot: "Three-three-four, one and three-quarter miles, right three, low glide path."

The pilot of 334 adjusts.

"Three-three-four, on glide path," CATCC reports. Then: "Three-three-four, slightly above glide path. On course. Three-quarter mile. Call the ball."

"Three-three-four, Hornet, ball 7.0."

As each airplane turns into its approach, the petty officer at the arresting gear board verifies the cable settings.

"Lens set. All set, F-18," the lens operator calls out to the air boss.

"Four set, three-three-four, F-18. Green deck," Peterson chants. "Shoot the ball."

The airplane lands. Another one is right behind it.

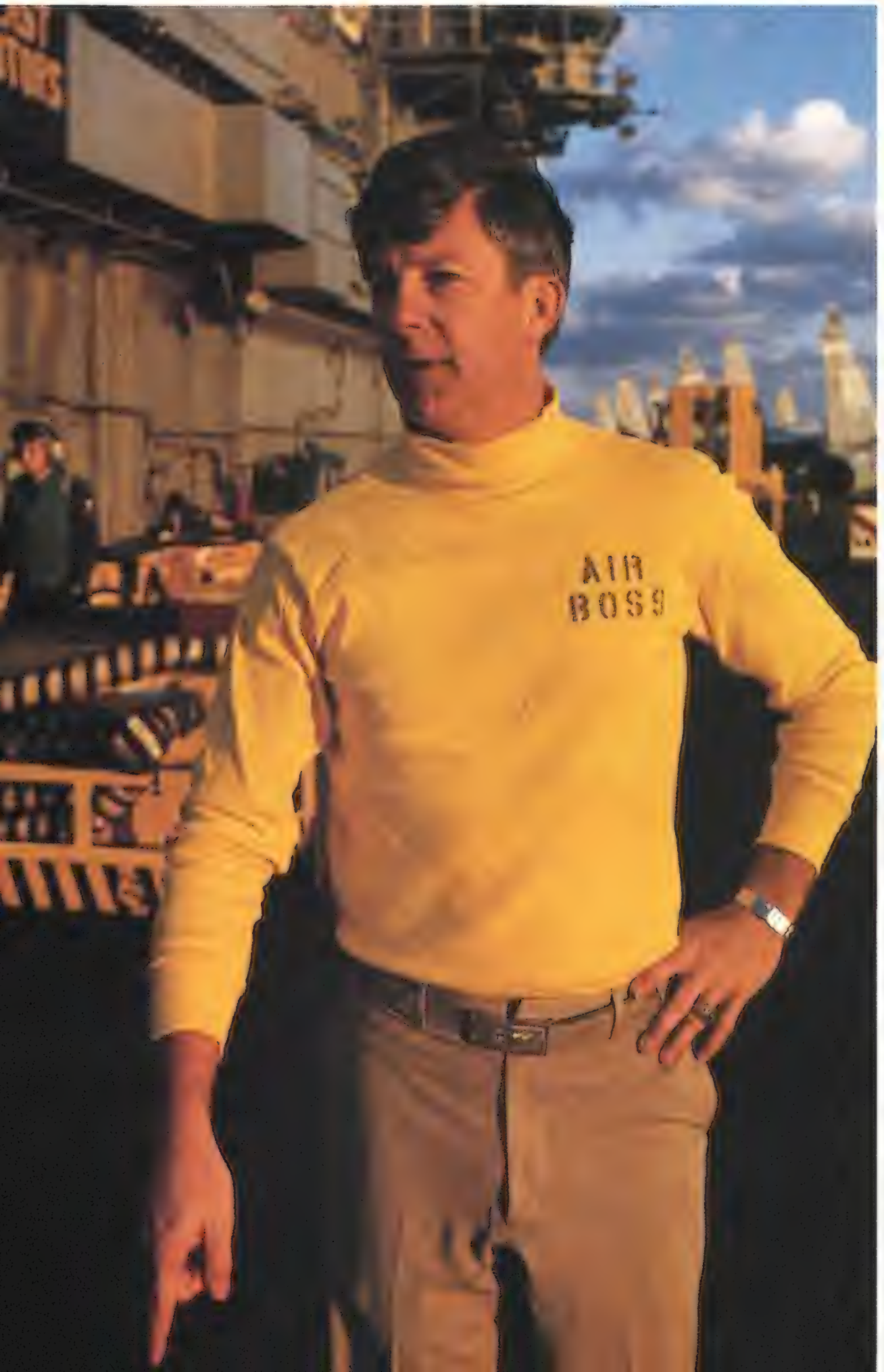
When things go wrong, Peterson's easy drawl becomes edged with sarcasm or restrained anger. He may chew on the end of a finger as he gazes out over the flight deck at an imperfect world. "Something usually happens during the course of a day that makes one evolution particularly hard," Peterson

says. "You get Excedrin headache number 49 and hope it's over. But a good flight deck can respond to those things and still keep an orderly flow."

Day CQs end near dusk, and Peterson and Jones take advantage of the lull before night operations to grab a quick dinner. Tonight it's pizza in the officer's mess, and the excitement is almost palpable. Pizza is a treat, and the boss wraps some in foil to take with him.

Peterson has been air boss aboard *Coral Sea* since June 1986, moving up after his apprenticeship as a miniboss. Soon he will be leaving for an 18-month stint at nuclear power school prior to an assignment as a carrier's executive officer. Will he miss being an air boss? "You bet," he says. "This is right where all the action is."

The ship gears up for night operations. It's clear, and a nearly full moon will make the pilots happy. Not far away, the flashing red lights of circling aircraft mingle with the stars. On deck, the taxi directors' light wands and the reflective tape on helmets and vests turn the crew into glow-worms. The soft lights inside Pri-Fly are soothing.



But tonight the gremlins are working overtime. Already the radios are emitting an irritating static, and a technician arrives to remedy the situation. "Hear that?" the miniboss asks him. "Make it go away." Then the LSOs lose one of their phones. Pressure in the arresting gear engines sinks, and no one can isolate the problem.

The lights of several F/A-18s twinkle in the distance. Their arrival will mark the start of a heavy schedule that could be thrown out of whack at a stroke. "Everything seems to squeeze down on you when you take light away," Peterson says. "It just gets tighter. The airplanes seem a lot bigger. The time seems to compress."

On the catapult, a single F/A-18 waits to be launched. "Three-three-six, you have a problem," the boss radios to its pilot.

The pilot misinterprets the statement as a question. "Negative."

The boss replies with quiet sarcasm, "You need to turn your lights on if you want to fly."

Three-three-six gets the picture. "Roger."

The helicopter lifts off the deck to take up its station.

"Lens on," the boss commands.

"Lens is on."

"Landing lights on."

"Landing lights on, boss."

Unhappy with the wind over the deck, the boss grabs his line to the helm. "Primary to bridge. Can we sweeten her a bit?" Moments later, the carrier begins a slight swing to align with the wind.

An F/A-18 slams onto the deck, traps, and taxis over to the catapults. The rest of the fighters are lined up in the pattern, spaced just minutes apart. But the interval between them is too great—they're wasting time. "A mile and three-quarters is a quarter-mile too much," the miniboss mutters.

The airplanes are piloted by Fleet Replacement Squadron pilots—new guys—and Pri-Fly is not terribly impressed with what it sees. "Power in the

wires!" the boss shouts into his mike at one pilot who throttles back before his hook has snatched a cable. The airplane would have gone into the water if it had boltered. The sparks from the hook hitting the deck during a bolter are spectacular at night, but the light shows waste precious time—"We deal in minutes," Peterson says—and after each one the boss shakes his head silently.

Soon the F/A-18s are joined by A-7 Corsair IIs, attack aircraft with huge air intakes that give them the look of largemouth bass. The airplanes' lights trace wildly erratic paths, but it slowly becomes apparent that the weaving is due to the ship's motion.

Now the pace is falling apart. An F/A-18 is on the catapult before Air Operations remembers that it needs a change of pilots. Another pilot thinks he may have dropped a flashlight on the flight deck. It could be sucked into an engine, so arrivals are waved off while deck personnel search. The pilot finds the flashlight; it had been in his airplane the whole time.

The F/A-18s complete their required landings. "Everyone we trap now is a keeper," Peterson says.

But the *Coral Sea* is an old lady with plans of her own. Launched in 1947, she is the second oldest carrier in the fleet, and the machinery is getting tired. The generators in the bow blow out, cutting off landing lights, catapults, and most of the radios in Pri-Fly. The boss and miniboss slump back in their chairs, feet up on the console. Night ops will end earlier than planned tonight, but it's already past midnight and no one in Pri-Fly pretends to be disappointed. It's been a long day, and tomorrow promises to be the same. The air boss breaks out the cold pizza.

Practice landings will grind on into the night, and the boss keeps working until the last airplane shuts down.

One quick nap and Peterson is ready for 20 more hours, during which he'll get to do it all over again.

A Case of Identity

Quick quiz: You've just landed at MCO. Where are you?*

*Orlando, Florida

by William Garvey

Airport identifiers, most familiar as the three-letter codes on baggage tags, are so much a part of air travel that we accept them without thinking. On the way to Miami, passengers know the MIA on the paper slips attached to their bags stands for their destination—not "Missing in Action." Off to Denver, and the boarding pass says DEN. When the Golden Gate is just off the wing, SFO lies dead ahead.

Some identifiers, such as LAX and JFK, have become part of almost every traveler's vocabulary. The logic of others is obvious even to non-travelers: MEM means Memphis, BOS is Boston, ATL stands for Atlanta, OAK is in Oakland, CLE means Cleveland, and IND is Indianapolis.

But who could guess that MSY means New Orleans International? That Orlando International's code is MCO? And why is Nashville Metropolitan known as BNA? Though these designators may seem to be aberrations, they really demonstrate how the identifier system is sometimes governed not by logic but by history, regulation, or arithmetic.

Identifiers date back half a century, when the Federal Communications Commission, which assigned IDs to the country's broadcast facilities, started giving two-letter codes to airport weather and radio stations. In most cases the local airports simply adopted the codes, which offered pilots, dispatchers, shippers, and travel agents a shorthand for jotting down operational information.

But as aviation grew, the two-letter system could no longer cover all the navigation aids, airports, air traffic control facilities, and U.S. Weather Bureau offices. In the 1940s the federal government switched to a three-letter system, and airports merely added another letter to their old identifiers: Omaha's OM was stretched to OMA and LA got its X. The FCC transferred the assignment of identifiers to the Civil Aeronautics Authority (which became the Federal Aviation Administration in 1967).

With the three-letter system, the CAA theoretically had a code pool of 17,576 combinations, but depletion set in almost immediately. First the FCC ruled that identifiers beginning with the letters K and W were reserved for commercial broadcast stations west and east of the Mississippi, respectively. Furthermore, the letter Q was part of a block of international radio signals and could not be used as the prefix for an identifier. Neither could X, which was withheld for test and temporary transmitter installations. The U.S. Navy copped the letter N for its own navigational aids. And finally, Canada got dibs on most of the identifiers beginning with Y and Z. The letter pool was down by a quarter.

A few long-established airports with forbidden identifiers—New Orleans Lakefront had NEW; Fairfax Municipal in Kansas City, Kansas, bore KCK—were allowed to keep them. But the restrictions would apply to all those that followed.

To preserve its remaining code pool, the FAA established eligibility standards for airports seeking three-letter identifiers: they must have at least a control tower, scheduled air carrier service, radio navigational aid, or weather service station on the field. Still, these requirements are met by thousands of airports, so the FAA has been cautious about handing out the approximately 5,000 identifiers it has remaining.

In certain cases—for instance, Ely, Nevada's ELY—assigning identifiers was simple. Others were more difficult. Sometimes the code makers simply began with letter two: Key West became EYW, Nome got OME, New Bedford, Massachusetts, gained EWB, and Needles, California, took EED.

Occasionally, the situations called for more roundabout solutions. Denied the prefatory K, the code makers decided the last would come first in Kansas City, Missouri, and labeled the city's downtown airport MKC. The much newer Kansas City International got MCI as a sort of variation on the theme.

Complicating matters further was the FAA rule that identifiers within 200 nautical miles of each other cannot be similar. The rule was born of experience. Code makers had given the District of Columbia's National Airport the identifier DCA, and when nearby Dulles International opened in 1962 it became DIA. But when pilots and controllers scrawled the Dulles identifier on flight plans and routing slips, the middle I was frequently mistaken for a C, and airliners intended for Dulles were sometimes routed up the Potomac for a landing at Washington National. The FAA considered the problem serious enough to change the Dulles designator to IAD.

The Dulles change was a rare case: government policy dictates that airport identifiers can't change. Pilots, controllers, baggage handlers, travel agents, and others use the codes regularly, and the confusion arising from changes could easily result in people, cargo, and even airplanes being misrouted.

There are also financial considerations. Changing an identifier requires revising all the computers operated by

the airlines, travel agencies, weather service, military forces, and the FAA. Scheduling, traffic, and communication forms would have to be revised and reprinted, and millions of baggage tags would have to be discarded and replaced. The FAA reports that the switch from DIA to IAD 20 years ago cost the industry $300,000, but the estimate for such an action today is over $1 million.

Exceptions are occasionally made. In the late 1960s and early '70s, for example, Maryland poured money into Baltimore's Friendship Airport with the goal of turning it into a major facility for residents of Baltimore, nearby Washington, and the surrounding suburbs. In a bid to lure vital Washingtonian business, the airport was renamed Baltimore-Washington International in 1973 and airport officials requested that the airport's identifier be changed from BAL to BWI.

The FAA refused, but the airport's backers didn't give up. There's no telling exactly whose arms were twisted or what political chits were cashed in, but in 1980 the FAA changed its mind. The airport became BWI.

Boosters of Knoxville, Tennessee's McGhee Tyson Airport tried altering the field's designator last year, but hit roadblocks on the local level. Because McGhee Tyson's TYS code doesn't identify the city it serves, a local airport operator suggested changing the code and possibly the airport's name as well.

The Tyson family quickly squelched the idea. In 1927 the Tysons had donated several hundred acres of land to the city for a park, with the stipulation that Knoxville's primary airport would always bear the name McGhee Tyson, after a family member who had died in the air corps during World War I. Ownership of the parkland would revert back to the family if the airport's name was ever changed.

Knoxville has scrupulously honored the terms of the gift. In fact, the current airport is the second to be named McGhee Tyson Municipal. The original facility fell to development years ago, but the name was transferred to its successor, just as the Tysons had desired. The name, and the designator, have not changed.

Local reaction halted another proposed designator change last year, when ski resort promoters at Vail wanted to switch their Eagle County Airport's EGE with Sac City, Iowa's SKI. Eagle County Airport officials reacted to the proposed change with a firm negative.

Reluctance to alter identifiers has resulted in some obscure letter combinations. But often the letters represent more than concrete, terminals, and parking lots.

New Orleans International—MSY—was originally Moisant International Airport, named in honor of John B. Moisant. A daredevil adventurer and celebrated flyer, Moisant thrilled the Crescent City with his aerial performances in December 1910. But the celebration ended on New Year's Eve, when Moisant's red Blériot crashed, killing its pilot.

Nashville Metropolitan's code is also based on history. When the field was finished in 1937 it was named Berry Field, in honor of Colonel Harry S. Berry, head of Tennessee's Works Progress Administration and the guiding force behind the airport. The airport was renamed in 1961, but the identifier, BNA, for "Berry, Nashville," remains.

There's also history behind Orlando International's MCO. Before it became the gateway to Disney World, the airport was McCoy Air Force Base, named in memory of Michael N.W. McCoy, a wing commander with the Strategic Air Command. Colonel McCoy and three other people were killed in a crash while practicing for an SAC bombing competition in 1957.

ORD represents Chicago-O'Hare International, but O'Hare's predecessor was a modest facility where Douglas Aircraft made C-54s during World War

II. The name? Old Orchard Field. It was ORD long before the greatly expanded field was renamed in honor of U.S. Navy pilot Lieutenant Commander Edward O'Hare, who died in 1944.

Some airports want to replace old, historical identifiers with more contemporary ones. For example, years ago Spokane International eclipsed its parent, Geiger Army Air Field, and now wants to retire its GEG identifier. Orlando airport officials feel the same way about MCO. But the code makers in Washington remain firm.

Although fairly strict about old identifiers, sometimes the FAA will assign codes to new airports that reflect a local characteristic. Vail didn't get SKI, but its cross-Rocky rival, Sun Valley, Idaho, did get its Friedman Memorial Airport labeled SUN. UOS is a seemingly meaningless identifier for little Sewanee-Franklin County Airport in Tennessee . . . but its proprietor is the University of the South. To most Ohioans, the letters OSU stand for the Buckeyes of Ohio State. They also identify the university's airport in Columbus.

Sometimes when an airport closes or a transmitter relocates, an identifier returns to the code pool. With its limited selection of codes, the FAA rarely allows a permanent retirement. It shelves the code until it has faded from memory, then quietly resurrects it.

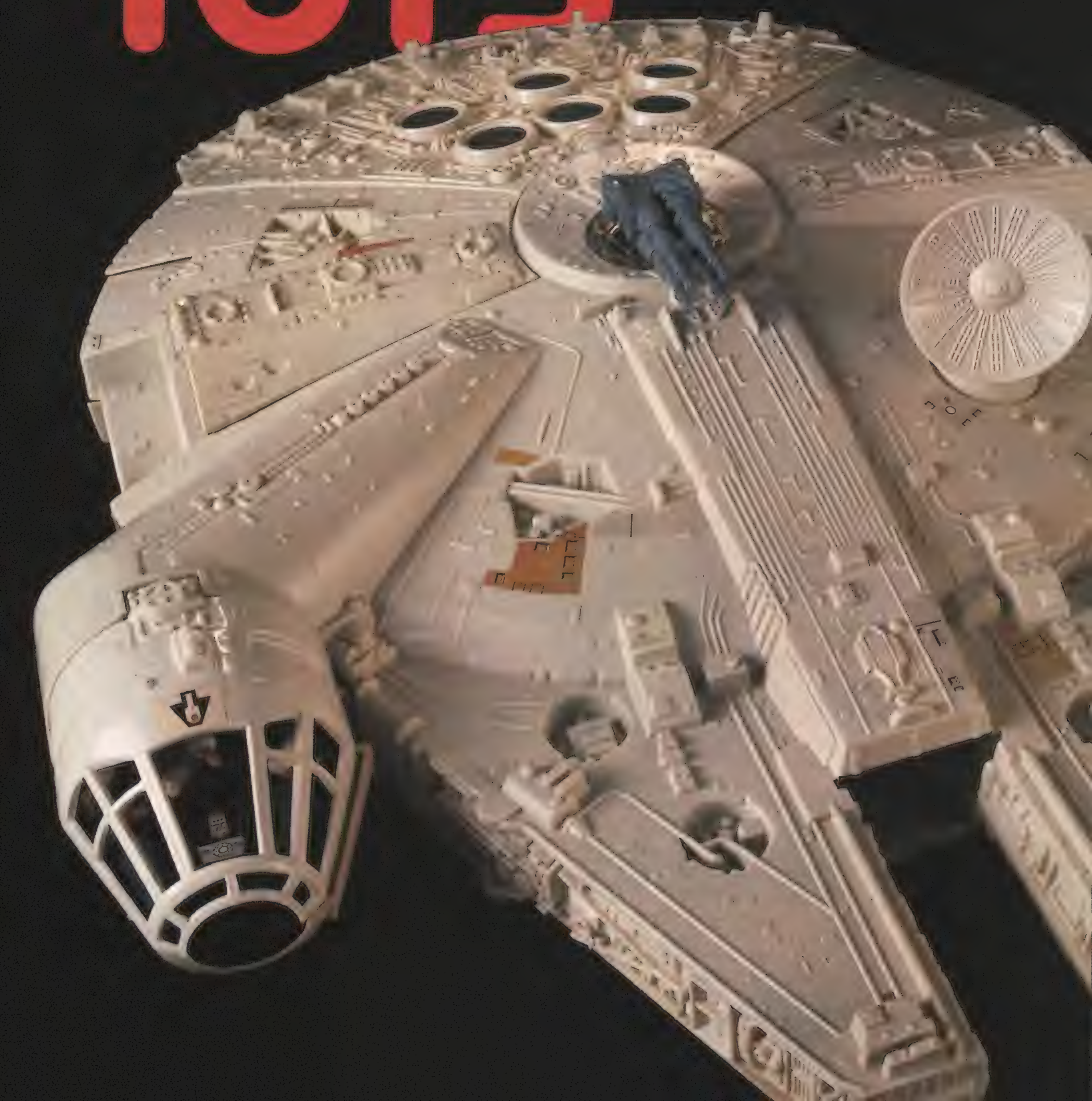
When New York's Idlewild jetport was rechristened John F. Kennedy International in 1963, the FAA broke with the rules and replaced its familiar IDL identifier with JFK. IDL remained stowed in the FAA closet for years, long enough for JFK to become firmly established in the minds of pilots, agents, and travelers around the world.

In 1971 the airport in Indianola, Mississippi—home for a few Cessnas and Pipers and a crop duster operation—received the IDL identifier. Indianola Municipal had been assigned three letters once recognized the world over. Because of the death of a president, as well as an unwieldy system full of barricades, politics, and tradition, tiny Indianola Municipal had inherited a little bit of history.

Caroline Sheen

SPACE TOYS

Collectors find that space toys are good for more than just fun and games.



by Devera Pine

Photographs by Charles H. Phillips

Big names become small figurines: the characters in all three Star Wars *movies made hot-selling dolls.*

John Glenn dolls, model lunar modules, talking R2D2 robots, inflatable space shuttles: hundreds of thousands of space toys like these are owned by apparently responsible, respectable, productive members of society. Otherwise average adults shop for toys wherever they go; they attend shows, such as the annual Kennedy International Antique Toy Convention held near New York's JFK airport; and they fill every shelf and closet in the house with their booty. They'll pay as much as $250 for a tin Buck Rogers Disintegrator gun.

What inspires these people to pursue the acquisition of what are, after all, children's playthings? For some enthusiasts, the hobby is a socially acceptable way of having the kind of fun only kids are allowed. Others find thrills in the search for yet another rare item. Some see their collections as miniature museums. And a few are frustrated astronauts, born too early to experience spaceflight firsthand: for them, the toys are consolation prizes. But all space toy collectors share a keen interest in space

Kenner's Millenium Falcon *wouldn't scare Darth Vader, but collectors like it.*

Even the Imperial Scouts' Speeder bikes from Return of the Jedi *inspired "action figure" toys (right).*

Buck Rogers' spaceship evolved from 1933 to 1939 (top right to left), but it never got as complex as Tom Corbett's 1950s model.

Mark Avino/NASM

exploration, real or imagined.

"With space you get flashes of interest because it's an adventure," says Tom West, former director of marketing for the model company Revell, Inc. To date, there have been three major flashes, each coinciding with actual or fictional space adventures. The first heyday came in the 1960s, when the space race and the astronauts were constantly in the news. Toy makers, always looking for a new motif for their products, responded by flooding the market with cheap, colorful Japanese-made space toys. "If something historic happened, the toy manufacturers would pick up on it," says Lloyd Ralston, who runs an antique-toy auction business in Fairfield, Connecticut.

So when the United States first ventured into space, lithographed tin Mercury capsules and plastic G.I. Joes in silver spacesuits soon followed. (Because the earliest metal space toys were made of tin, collectors tend to refer to all metal toys—even the more recent models made of light steel—as "tin.") The spacewalks of the Gemini program generated toys featuring two astronauts, one of whom "floated" outside the craft. And the Apollo era brought forth a plethora of kid-size command, service, and lunar modules. These early toys are now by far the most coveted, says Ralston.

West Coast collector Bernard Passion specializes in this era. In fact, Passion limits his hobby to items related to *Apollo 11*. His 10,000-piece collection of memorabilia from the first manned lunar landing includes about a dozen space toys. One, a plastic rocket, features a service module that spins around and docks with the lunar module when the toy is turned on.

Joshua Stoff, curator of the Cradle of Aviation Museum in Garden City, New York, became a toy collector because he was interested in space: "I couldn't collect the real things, so . . . " He sees his 200 or so toys as "material history." Each toy—from a tin Sputnik bank to two dozen lunar modules to a model of the space station—is both a historical artifact and a scaled-down version of the real thing, documenting the history of spaceflight right in his living room. "It's like having a space museum on the shelves, complete with rockets, capsules, and astronauts," he says.

The second wave of popularity came with the release of the movie *Star Wars* in 1977. For some, the film brought back memories of watching a launch on television while playing with a tin *Friendship 7* capsule, complete with a tiny John Glenn doll inside. For others, *Star Wars* simply renewed an interest in space and science fiction. In any case, the movie started a craze for collecting both old and new space toys.

Jeff White, a collector and dealer from Huntington, New York, probably has one of the biggest collections of *Star Wars* memorabilia in the country—6,000 pieces, all bought within three years. Among his toys: a scarce talking

The first in a long line of toy space guns: Buck Rogers' 1930s vintage Disintegrator gun (top).

British toy company Dinky produced this version of Star Trek's starship Enterprise *in the 1970s.*

R2D2 that says, "Bleep, bleep. The rebels are coming."

Stephen J. Sansweet credits *Star Wars* with rekindling childhood memories and inspiring his collection. After he saw the movie, he says, "I got one toy. Then I got ten. Then I would send a thousand-dollar check to a dealer and get twenty." Eventually Sansweet had to add two floors to his home to accommodate his 10,000-piece collection, which today includes space toys and

Space toys sell well around the world (counterclockwise from left): a Latvian-made battery-operated crawling toy based on the Soviet lunar vehicle Lunakhod 1; a Chinese "Universe Televiboat"; Russian wooden folk dolls in the form of Matryoshka Cosmonauts; and the Japanese Spaceship X-8, which features "bump and go action with a beep beep sound."

Mark Avino/NASM

Dinky created this alien-spaceship interceptor, S.H.A.D.O., *as a tie-in to the movie* UFO.

Star Wars memorabilia ranging from pillowcases to posters from around the world.

Sansweet, Los Angeles bureau chief of the *Wall Street Journal* and author of the book *Science Fiction Toys and Models,* does most of his shopping at shows, antique and collectibles stores, and through the mail. But he has no qualms about going to the local Toys R Us to buy whatever current space toys appeal to him.

Sansweet says he doesn't dare calculate how much he spends on toys. But he has his reasons: "I grew up at the same time as the space program," he says. "I can remember feeling heartbroken each time a rocket blew up on the launch pad. And when I was really small, I loved to watch 'Tom Corbett, Space Cadet' and other space shows." But even he admits that 10,000 toys constitute more than just a hobby: "Sure, it can be obsessive if you start to get a lot of stuff. But . . . it's very different from what I do at work; it gives me a chance to have fun."

The third surge of interest may be the biggest of all, and it's still going. "If you think back to the '60s, there weren't nearly as many Mercury, Gemini, and Apollo toys as there are shuttle toys," notes collector Kerry Joels. It may be that we have a more commercial culture now, or simply that people can relate better to a vehicle that has wings and a tail—as Joels puts it, "It's hard to make an interesting toy out of a gumdrop." Whatever the reason, the profu-

Interlocking plastic proved the perfect medium for a Soviet-made Apollo-Soyuz toy.

sion of shuttle toys reflects a broad interest in the space program—interest that has held steady despite the *Challenger* accident. In fact, toy company representatives say that the explosion actually drove up sales. "There was so much media hype that we couldn't keep ahead of it," says a spokesman for Ertl, which makes die-cast metal toys, including shuttles.

Joels, a former curator at the National Air and Space Museum and coauthor of *The Space Shuttle Operator's Manual,* specializes—not surprisingly—in shuttles. He got started with a toy shuttle purchased with his first royalty check from the book. "I thought, 'Gee, now I can afford to do this'—not realizing that many of the toys cost $20 to $30." Eighty toys later, Joels has a closet stacked floor to ceiling with boxed shuttles. His collection includes cheap plastic shuttles that spark when you rub their wheels on the floor, a burnished metal shuttle sculpture that plays "Fly Me to the Moon," and a rare toy shuttle mated by mistake to a DC-10 instead of a 747.

The Daishan Kogyo Co. Ltd. of Japan went all out to replicate the Apollo lunar lander Eagle.

A tin Hungarian rocket toy (top right), complete with tiny astronaut, is a model of simplicity.

Joels, now director of education programs for the Young Astronaut Council, looks for toys wherever he goes. For him, collecting toy shuttles is more than just a hobby. "I'm interested in the shuttle and its impact on society," he says. Toys tell you what a society values, and Joels believes that shuttle toys are popular because space exploration is an achievement that marks our time.

Already, space toys can sell for hundreds of times their original prices. A typical NASA space capsule toy that sold for under $10 in the late '60s now brings up to $300, according to Sansweet.

The price of a toy depends on a number of things. Rule one: the smaller the supply, the higher the price. For instance, after an eight-year production run, Kenner Products has finally stopped making *Star Wars* toys. R2D2 dolls that sold for $25 at shows last year can't be had now for less than $125. Says collector-dealer White, "It's name your price."

A toy in good shape—one that still lights up, whirls around, makes noises, and has all of its parts—is also more valuable. But good toys are hard to find. "Toys are different from other antiques because they get thrown on the floor"

Spaceships have long been popular with both kids and collectors (clockwise from bottom left): G.I. Joe's capsule from the 1960s; a somewhat less realistic Cabbage Patch ensemble of the 1980s; a 1970s Japanese "Moon Traveller"; and a fanciful Indian toy, complete with flashing red nose cone.

when they're new, says Gary Darrow, owner of Darrow's Fun Antiques in New York City.

Toys still paired with their original boxes fetch even higher prices. At Darrow's, a Cragstan astronaut that sold for $5.79 in 1959 now goes for $1,500 with the box, $900 without it.

A final price guideline: the bigger and more complex the toy, the more it costs. A small red and gray Eagle lunar module that scuttles around flickering its lights, for example, recently carried a price tag of $150 at Darrow's. But a red and white Apollo capsule that flashes its lights, makes a beeping noise, and rotates a "spacewalking" astronaut attached to the craft by a wire was selling for twice as much.

Space toys are now considered legitimate museum pieces, too. At the Kansas Cosmosphere and Space Center in Hutchinson, a "Moon Mania" display highlights "social artifacts" of the Apollo program. Among the toys exhibited are an *Apollo 11* jigsaw puzzle,

Roger Ressmeyer

launchable plastic Saturn rockets, an inflatable astronaut, and a special-edition Tang container that melts into an Apollo command module toy when baked at 350 degrees for seven minutes.

The Lawrence Scripps Wilkinson Collection of Toys, a traveling exhibition program affiliated with the Detroit Historical Museum, has about 50 space toys, all picked by founder Larry Wilkinson. A retired vice president of F.A.O. Schwartz, Wilkinson looked mainly for toys based on actual NASA vehicles.

Being future-oriented types, space toy aficionados may well wonder how their collections will appreciate. Will a $40 Young Astronaut Cabbage Patch Kid be worth five times as much 20 years from now? Will shuttle pencil sharpeners become priceless museum pieces? There's no way to tell. "Give these toys another 20 years, keep them in their original boxes, and you're going to wish you had bought a truckload," says antique dealer Ralston. The key, though, is to buy the right ones. "It's like buying stock," he says.

Sansweet, however, feels that investment is not a good enough reason for collecting. "Who knows what's going to happen 10 or 20 years from now? You could get burned."

In the meantime, one thing seems certain: as long as there's a space program, there will be space toys. And in the 21st century, when laser-fusion craft start pulsing their way toward distant suns, you can bet that kids—young and old—will have miniature plastic versions to push across the living room floor.

While collectors keep their toys on a shelf, kids are more likely to put them through their paces (left).

Fresh off the Hasbro drawing boards is the G.I. Joe Friendship Capsule ("action figures sold separately").

There's more than meets the eye to the shuttle/autobot below, part of Hasbro's Transformer series.

Shuttles, shuttles everywhere: space shuttles are now the most popular space toys on the market (right).

Mark Avino/NASM

Mark Avino/NASM


USA
United States

Mark Brender, Reporting from Space

A Washington journalist is working to guarantee that his colleagues have unrestricted access to space.

by Harry Jaffe

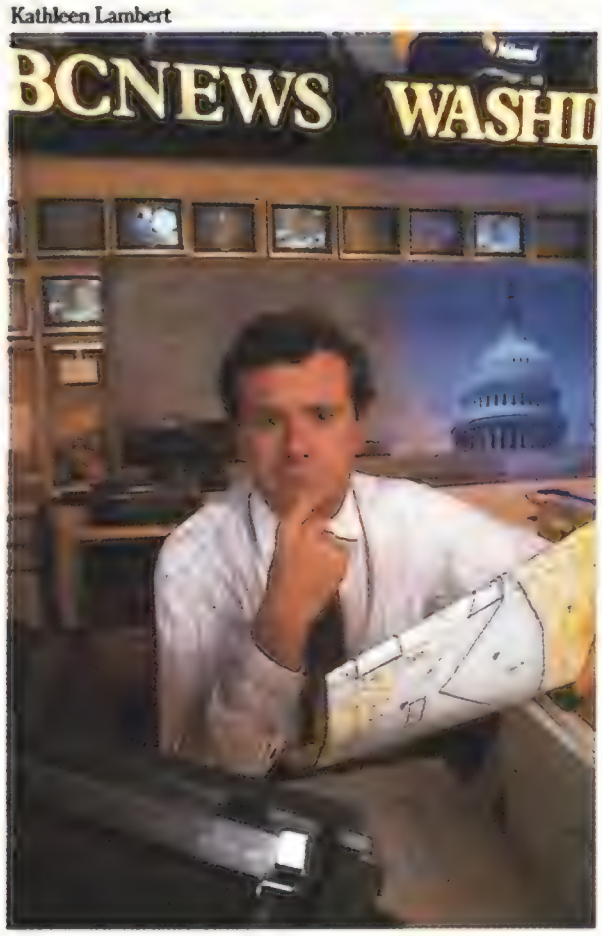
A Congressional committee was looking into commercial uses of satellite imagery last spring, and Mark Brender of ABC, wearing his best gray pinstripe suit and a serious look behind his wire-rim glasses, came to testify about the prospects for newsgathering in space. Brender related an incident in which an astronaut on the shuttle took a photograph of Earth that happened to include Moscow. The National Aeronautics and Space Administration would not release the photo, claiming it was too sensitive. Recounted Brender: "I told NASA that it can't classify Earth!"

With a carefully restrained measure of outrage, Brender will share his favorite examples of censorship in outer space with anyone who will listen. A television news journalist, he has made it his mission to protect the media's First Amendment rights in space.

Brender, 38, is ABC's national security assignment editor, a job that involves tracking worldwide events and correspondents from a desk surrounded by monitors and telephones. It was his daily view of Earthly events through the TV cameras that allowed him to see the potential of space-based newsgathering. "I'm a worldwide voyeur," he says. "The next logical place for me to put a camera is in orbit." During his testimony before Congress, Brender elaborated: "The media is constantly being manipulated. The Iraqis call me at the news bureau and claim they've raided an Iranian oil field. Two minutes later the Iranians call to say it's not true. If I can get an image from space showing the burning oil field, that's the truth. That's news!"

If newsgathering from space catches on, he adds, the media may decide to launch their own remote sensing satellite—a "mediasat," as Brender calls it.

Kathleen Lambert



Mark Brender has prodded journalists and politicians to think about newsgathering from space.

The oldest of three sons, Brender spent his childhood moving every two years in tune with his father's assignments as a Navy pilot. Instead of protesting the Vietnam War, he joined the Navy ROTC and signed up for a hitch the day after graduation. His Navy career took him to flight school, then aboard ship as a navigator, back to college for a master's degree in public relations, and to Europe as a public affairs officer for the Sixth Fleet. In 1981, after a decade in the service, he decided "it was time to unplug the Navy umbilical cord and move on in life."

He landed at the ABC news bureau in Washington, D.C. There he had a chance to observe the flow of news and think about how to improve coverage. "I saw that there were a whole lot of words and images on TV but not much information that was verifiable about certain sensitive issues. So I started to think of ways we could see places that we were barred from, like South Africa and Iraq . . . . One of the bloodiest wars in the last 20 years is going on between Iraq and Iran right now. It will have tremendous impact on the Middle East and oil prices, yet you can't see it. I figured there must be a way.

"Originally," he continues, "I had a vague interest in newsgathering from space . . . . But I got aroused talking to people. I realized I had a keen issue with a potentially great impact on journalism. I spoke to anyone who would listen. I felt it was time to take it into the public domain to test the reception."

The National Association of Broadcasters wasn't interested. However, the Radio and Television News Directors Association liked the idea and invited Brender to create a media-in-space task force in early 1985. "He was the leader from the beginning," says Ernie Schultz, president of the directors' organization. "We would not have known, if not for Mark's perception, that this technology had tremendous applications for newsgathering."

As head of the task force, Brender started writing articles on First Amendment rights in space. And when he caught wind of NASA's plan to send a journalist on the shuttle but restrict what the journalist could do in orbit, he spoke up again. Journalists are entitled to the same rights in space that they have on the ground, he told NASA, and they should be able to report whatever goes on during their space mission, "whether it's a dispute among astronauts or a damaging meteor shower. Otherwise it's censorship."

By the end of 1985, Brender had gained some renown, but his issue wasn't getting hot because journalists still weren't using satellite pictures. Imagery from the Landsat remote sensing satellite was for sale, but the best resolution it offered was 30 meters. "To me," says Brender, "30-meter resolution is art, not news."

In February 1986, however, the French company SPOT Image launched a commercial remote sensing satellite that provided 10-meter resolution. On April 26, the Soviet Union's Chernobyl nuclear power plant blew. EOSAT Company of Lanham, Maryland, released 30-meter color Landsat images of the disaster area on April 30; it was thermal radiation data contained in this imagery that showed Chernobyl's "hot spot." SPOT Image released 10-meter black-and-white images on May 1. ABC showed the Landsat pictures on April 30 and the SPOT pictures on May 1. Brender had to call in an interpreter to decipher the imagery, but the pictures shown on May 1 were the sharpest available of the Chernobyl plant.

The era of newsgathering from space had begun. Newspapers and magazines started publishing stories about satellite pictures, and Brender was the spokesman and the instigator for many of them. The question of First Amendment rights in space was debated all over Washington. His cause was finally legitimate.

A year later, ABC aired a precedent-setting story based on satellite imagery. For years, the Reagan administration had accused the Soviet Union of violating the 1972 Antiballistic Missile Treaty by building a radar station near Krasnoyarsk, Siberia, to detect ballistic missiles. U.S. officials based their claim on classified pictures from spy satellites. The Soviets denied the claim but offered no proof that the Americans were wrong.

The news story began with a satellite

EOSAT/SPOT Image/EROS Data Center

Top: The Chernobyl plant is barely visible in a 30-meter-resolution Landsat image made after the accident.

Bottom: Chernobyl's "hot spot" shows up red after merging and enlarging Landsat and 10-meter SPOT imagery.

image that Brender had ordered several months earlier, when he identified Krasnoyarsk as a target for the SPOT satellite. The image that came back looked about as revealing as an abstract painting. But an arms control expert pointed out what he said was a radar receiver the size of a football field.

In this case, satellite imagery corroborated the U.S. government's position. But what would happen if the government decided that public display of a satellite image threatened national security? Suppose a picture revealed a nuclear test range or U.S. aircraft carriers cutting through the Persian Gulf?

According to Brender, his media colleagues, and a host of First Amendment lawyers, the government has so far avoided guaranteeing the unrestricted use of images from space. Federal law requires the licensing of commercial remote sensing satellites and allows the government to deny a license if it decides that the operation of a satellite might threaten national security. Brender calls that potential censorship and prior restraint.

The question of censorship in space will probably not be resolved until a sensitive image is made public or the media officially request a license to launch a mediasat. The courts would likely uphold the media's right to use satellite imagery, says a legal expert at the Congressional Research Service, but the government could take a media organization to court if it decided that releasing such information had violated national security.

Officials who favor restricting the media's use of satellite imagery often ask whether the press can exercise its freedom without betraying state secrets. Suppose the United States were preparing a surprise attack on Nicaragua, and a network aired satellite pictures of troops massing along the Honduran border . . . ?

When Brender addressed the congressmen the question came up. "I knew about the invasion of Grenada two days before our troops landed, but we kept that secret," he testified.

The government isn't alone in its wariness. Some experienced image interpreters are critical of the media's use of satellite imagery to date, claiming that journalists don't know what they're looking at. Earl Merritt, vice president of Earth Satellite Corporation, an image interpretation company in Washington, says media organizations first need to invest in developing interpretation skills. For now, media use of satellite pictures is just "a gee-whiz application," he says.

Brender agrees that journalists have a lot to learn before they can use satellite imagery routinely. In school, he says, "I was terrible at hard sciences and never really interested in space. I'm the last person in the world to get into high-tech issues—but this is not a high-tech issue. We're talking about the public's right to know and to see newsworthy images of Earth."

Despite Brender's enthusiasm, mediasats are still an idea, not a plan. Brender admits that the networks may never be willing to spend the $50 million to $100 million that aerospace companies have estimated a mediasat will cost—he's hoping someone else might launch one and sell the service to the networks. And there are a number of technological limitations as well. "I

What's in an Image?

The first time one Swedish reporter saw satellite pictures of the Iran-Iraq war zone, a Soviet naval base, and an Israeli nuclear plant, she said they looked like "pictures of breadcrumbs and dried-up coffee stains."

She wasn't alone. Many of the 75 journalists, researchers, and military officials who viewed the images at a meeting in Stockholm early this year were just as confused. Without extensive training in image interpretation, it is virtually impossible to decipher satellite imagery.

The difficulty of correctly interpreting and productively using pictures taken by remote sensing satellites was a central theme at the meeting, organized by the Swedish Institute of International Affairs to study the use of satellite imagery for national security research. "These images need to be independently checked and analyzed carefully," said Christer Larsson, director of Sweden's Space Media Network, a company that markets pictures from the French SPOT satellite to the international news media. Proper interpretation depends on detailed knowledge of the area in a satellite picture—"ground truth"—as well as years of experience working with satellite imagery.

Inaccurate analysis of satellite pictures is not only embarrassing; it can be politically risky as well. In March, for example, the *London Observer* published a satellite picture that it claimed showed a uranium enrichment plant at Kahuta, Pakistan. The newspaper was interested in this picture because Western observers say Pakistan is trying to expand the Kahuta facility, allegedly in an effort to build up a nuclear weapons production capability. "What they published and claimed to be Kahuta," said Larsson, holding up a copy of the unfortunate article, "is actually a site 10 miles away to the west. It was a complete mixup."

A spokesman for the *Observer* said the paper had relied on an outside consultant to interpret the Kahuta picture. This incident highlights the need for media organizations to find interpreters who have skills suited to particular types of stories. An interpreter specializing in geologic satellite data might do well with images of a volcanic eruption or a newly discovered mineral deposit, but not with pictures of nuclear facilities.

As their resolution improves, commercial satellites could play a role in verifying arms control agreements, said Peter Zimmerman, a senior associate with the Carnegie Endowment for International Peace in Washington, D.C. However, interpretation problems and current political opposition could stand in the way of establishing a space-based arms control verification system.

Larsson's company, which gained notice when it released images of the burning Chernobyl nuclear plant last year, has had its own troubles interpreting some imagery. In mid-1986, the company obtained SPOT satellite pictures believed to show Israel's classified Dimona complex, where that government is said to be making fuel for nuclear weapons. More than a year later, Space Media Network has still not released the pictures because it has not found an interpreter who can identify certain details in them. "We don't go public before we're 100 percent—or at least 99 percent—sure," Larsson says.

—David Bartal

Top: A 30-meter-resolution Landsat color picture of Sun City, Arizona, provides a blurry view of urban development. Color helps identify soil, vegetation, and water.

Middle: Merging SPOT and Landsat imagery by computer processing yields a 20-meter-resolution picture that tells more about Sun City than a Landsat or a SPOT picture alone.

Bottom: With its 10-meter spatial resolution, a black-and-white SPOT picture reveals more of Sun City's features, but without the depth of information that color provides.

EOSAT/SPOT Image/EROS Data Center

don't want to oversell this technology," Brender says. "It can't see people. It can't hover over a news area feeding you a live picture of what's going on." Nor can it observe the same spot on Earth every day. And it can't see through clouds, so much of the world will remain obscured much of the time.

But Mark Brender is a patient man. He waited three years before people caught up with his concept of journalism in space. He can wait a while longer to see a mediasat launched. "Americans have a love affair with space, with communication, with images," he says. "It's a natural." ✈

Blithe Spirit

A friend of mine in her early 50s recently bought an airplane. Leonie felt remote on her Virginia Eastern Shore creek, so to shorten the route to her writing assignments and to her parents in Baltimore, she got a pilot's license and a second-hand Beechcraft Sport, in which she can carry two passengers and either a large duffel or her two dogs.

In a snapshot taken by her flight instructor, Leonie stands in front of the airplane, holding the older dog, Sweet Pea, in her arms. She looks confident, yet a little surprised, perhaps at her success in achieving the goal of flight. The wind is blowing Sweet Pea's long ears so they stand out at the precise sprightly angle of the airplane's wings. Airplane and dog wear a thumbs-up expression, like two survivors.

The true survivor of the trio is Leonie. Fifteen years ago I sat with her at a Baltimore psychiatric hospital and listened to her father tell her how awkward her breakdown was for him and Leonie's mother. "We don't know what to tell anyone," he said.

Nor had she. In the 30 years of our friendship, I had seen Leonie frustrated in each attempt to break through the web of polite evasion that for her only passed for life. Women of our generation and background were expected to marry, raise children in station wagons, and do volunteer work. Leonie and I succumbed to middle-class 1950s marriages: preparing leisurely Friday night dinners at each other's houses, pushing our first babies in strollers, hurrying home to create five o'clock perfection for our husbands. Over

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the years, we spent occasional weekends at the beach with an expanding brood of children, comparing notes.

Leonie studied the apparent ease with which I breathed in our constricted domestic world. For me, the years with young children were good—absorbing physical energy, returning small surprises. There were silences that allowed the mind freedom to rove. Not so for Leonie. She sought variety, cooking up games, theatricals, and home businesses one after another, baffling family and acquaintances who found reassurance in routines. She dreamed of learning to fly and latched on in a burst of elated chatter to anyone whose life seemed to be in motion. She decamped in the early 1970s and was trying to support herself and her two children when a casual, cruel remark snapped her tentative belief in herself. One afternoon she took too many pills and called me for help.

A month later, on the hospital's lawn, she countered her father's complaint gently, reassuringly. She got through therapy in three months, half the projected time, and quickly took charge of her life. She found a job and a place for her and the children to live. Since then she has taken up a freelance existence. She and her new husband write stories, take photographs, rebuild houses, and continually redefine the terms under which they live together, trying to keep in balance the shifting needs for motion and rest. Sailors as well as fliers, they know both the delights and the dangers of a fluid medium.

When she called one brilliant Saturday last fall with an invitation to fly, I jumped at the chance. I met her father at the general aviation terminal at Baltimore-Washington International Airport, where we shouted pleasantries at each other over the high-pitched snarl of a weed-eater at work nearby. We watched with some apprehension for a small blue and white airplane in the rhythmic procession of airliners. Finally we saw the Beechcraft land; as it taxied closer, we could hear its engine, loud and smooth, over the weed-eater's din, and make out Leonie at the helm and Sweet Pea in the back seat. On the ground, the craft looked like a toy, half as solid as my Subaru.

Leonie's father greeted her heartily, but his expression was tense as he climbed into the airplane. He seemed to realize he was trusting himself to the unlikely aeronautical expertise of his maverick girl-child. He followed her gestures with wide eyes as she told us how to communicate with hand signals, explaining that engine noise would soon make conversation difficult.

Leonie adjusted her headset, spoke in an incomprehensible jargon to the control tower, and revved the engine. She put a hand on her father's knee and over the blast shouted something to him that made him laugh. We began to move toward the runway, and within moments, the tarmac had dropped away beneath us.

When we leveled off at 3,000 feet, he peered down, fascination overcoming apprehension. We were low enough to take in the pinking shear pattern of waves on the Chesapeake Bay but high enough to watch the Eastern Shore of Maryland materialize in a bas-relief map.

There was last spring's bike trip—Oxford's Main Street, the ferry cutting a wake across the Tred Avon, the blacktop road winding past plantation houses and roadside cabins to the town of St. Michaels—all reduced to the scale of a Parcheesi board.

We circled Leonie's house and its pattern of gardens and fields on the bend of a creek. She knew that pattern as well as she knew her stubborn kitchen door and the daffodils waiting beneath the soil. From her airplane, she had grand design and minute detail in focus simultaneously.

We flew northward to the Blackwater National Wildlife Refuge, where migrating birds stop for rest and refueling each spring and fall. I had walked there in July, spotting the resident bald eagle posing in a dead tree, and I had driven through in November as clouds of ducks, whistling swans, and Canada geese wobbled and dove down into cornfields and reeds at the water's edge, the air raucous with their calls. Now there stretched below us a quivering filigree of brown and silver. Water coiled through the marsh in shimmering ribbons. What appeared to be earth at one moment dissolved into water the next. The finely tuned ecology we read about—salt and fresh water, birds, fish, vegetation, and nitrogen—breathed in a fragile balance. The marsh seemed a fleeting illusion, existing only in the moments it flashed under our airplane's wings. It seemed precious in its transience, and so did we.

I grabbed Leonie's shoulder and pointed down. She laughed, then banked and circled the Beechcraft so we could watch the marsh flow under our shadow again. The freedom her airplane gave her was a gift she gladly shared.

—Brooke Hearn

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Carrying the Fire

Had things gone according to plan, Michael Collins would not have been on the first manned moon mission. An Air Force test pilot at Edwards Air Force Base, Collins had joined the space program in 1963 and served as the co-pilot on the Gemini 10 flight in 1966. Two years later he was assigned to Apollo 8, but when a medical problem required surgery he was reassigned to Apollo 11. The pilot of the command module (CM) Columbia, *Collins would wait in moon orbit as Edwin "Buzz" Aldrin and Neil Armstrong took the bug-like lunar module (LM)* Eagle *to the surface.*

Apollo 11 lifted off from Florida on July 16, 1969, boosted by a Saturn V rocket onto a quarter-million-mile trip that took four days. Collins wrote about the experience in his book Carrying the Fire.

Day 4 has a decidedly different feel to it. Instead of nine hours' sleep, I get seven—and fitful ones at that. Despite our concentrated attempt to conserve our energy on the way to the moon, the pressure is overtaking us (or me at least), and I feel that all of us are aware that the honeymoon is over and we are about to lay our little pink bodies on the line. Our first shock comes as we stop our spinning motion and swing ourselves around so as to bring the moon into view. We have not been able to see the moon for nearly a day now, and the change in its appearance is dramatic, spectacular, and electrifying. The moon I have known all my life, that two-dimensional, small yellow disk in the sky, has gone away somewhere to be replaced by the most awesome sphere I have ever seen. To begin with, it is huge, completely filling our window. Second, it is three-dimensional. The belly of it bulges out toward us in such a pronounced fashion that I almost feel I can reach out and touch it, while its surface obviously recedes toward the edges. It is between us and the sun, creating the most splendid lighting conditions imaginable. The sun casts a halo around it, shining on its rear surface, and the sunlight which comes cascading around its rim serves mainly to make the moon itself seem mysterious and subtle by comparison, emphasizing the size and texture of its dimly lit and pockmarked surface.

To add to the dramatic effect, we find we can see the stars again. We are in the shadow of the moon now, in darkness for the first time in three days, and the elusive stars have reappeared as if called especially for this occasion. The 360-degree disk of the moon, brilliantly illuminated around its rim by the hidden rays of the sun, divides itself into two distinct central regions. One is nearly black, while the other basks in a whitish light reflected from the surface of the earth. Earthshine, as it's called, is sunlight which has traveled from the sun to the earth and bounced off it back to the moon. Earthshine on the moon is considerably brighter than moonshine on the earth. The vague reddish-yellow of the sun's corona, the blanched white of earthshine, and the pure black of the star-studded surrounding sky all combine to cast a bluish glow over the moon. This cool, magnificent sphere hangs there ominously, a formidable presence without sound or motion, issuing us no invitation to invade its domain. Neil sums it up: "It's a view worth the price of the trip." And somewhat scary too, although no one says that.

If anything, the rear side of the moon looks even rougher than the front. It doesn't have any "flat" maria, or seas, as the front does, but is a continuous region of "highlands," an uninterrupted jumble of tortured hills, cratered and recratered by 5 billion years of meteorite bombardment. There is no atmosphere surrounding the moon to produce clouds or smog or otherwise obscure the surface, so the details are uniformly clear. CAVU, as pilots describe a perfect day on earth: clear and visibility unlimited. The only thing that changes is the lighting, as our spacecraft passes from sunshine into earthshine . . . and then into total darkness . . . . The earth from orbit is a delight—alive, inviting, enchanting—offering visual variety and an emotional feeling of belonging "down there." Not so with this withered, sun-seared peach pit out my window. There is no comfort to it; it is too stark and barren; its invitation is monotonous and meant for geologists only. Look at this crater, look at that one, are they the result of impacts, or volcanism, or a mixture of both?

As three amateur geologists, it doesn't take us long to get caught up with the mystery of the place and the fascination of discovering new craters on the back side. "What a spectacular view!" exclaims Neil. I agree. "Fantastic. Look back there behind us, sure looks like a gigantic crater; look at the mountains going around it. My gosh, they're monsters." Neil points out another one, even larger, and I'm even more impressed by it. "God, it's huge! It is enormous! It's so big I can't even get it in the window. That's the biggest one you have ever seen in your life. Neil, God, look at this central mountain peak. Isn't that a huge one?"

Now it is time for Neil and Buzz to get dressed, and they begin by pulling their lunar underwear out of storage bins. These garments are liquid-cooled, with hundreds of thin, flexible plastic tubes sewn into a fishnet fabric. The back pack they will wear on the lunar surface will pump water through these tubes, cooling their bodies much more efficiently than could be done simply by blowing cool oxygen over them. I don't need water-cooled underwear because I don't have any back pack, and because hopefully I won't be working that hard, but I do require a pressure suit, so all three of us struggle into them, helping each other with inaccessible zippers and generally checking the condition of each other's equipment . . . . Fortunately, everything seems to fit together, and I stuff Neil and Buzz into the LM along with an armload of equipment . . . .

I formally bid them goodbye. "You cats take it easy on the lunar surface; if I hear you huffing and puffing, I'm going to start

Orbiting the moon in the command module Columbia, *Michael Collins experienced a unique sense of solitude.*

NASA

NASA

bitching at you." "O.K., Mike," Buzz answers cheerily, and I throw the switch which releases them . . . .

"O.K., *Eagle* . . . you guys take care." Neil answers, "See you later." I hope so.

Meanwhile, the command module is purring along in grand shape. I have turned the lights up bright, and the cockpit reflects a cheeriness which I want very much to share. My concerns are exterior ones, having to do with the vicissitudes of my two friends on the moon and their uncertain return path to me, but inside, all is well, as this familiar machine and I circle and watch and wait. I have removed the center couch and stored it underneath the left one, and this gives the place an entirely different aspect. It opens up a central aisle between the main instrument panel and the lower equipment bay, a pathway which allows me to zip from upper hatch window to lower sextant and return. The main reason for removing the couch is to provide adequate access for Neil and Buzz to enter the command module through the side hatch, in the event that the probe and drogue mechanism cannot be cleared from the tunnel. If such is the case, we would have to open the hatch to the vacuum of space, and Neil and Buzz would have to make an extravehicular transfer from the LM, dragging their rock boxes behind them. All three of us would be in bulky pressurized suits, requiring a tremendous amount of space and a wide path into the lower equipment bay. In addition to providing more room, these preparations give me the feeling of being proprietor of a small resort hotel, about to receive the onrush of skiers coming in out of the cold. Everything is prepared for them; it is a happy place, and I couldn't make them more welcome unless I had a fireplace. I know from pre-flight press questions that I will be described as a lonely man ("Not since Adam has any man experienced such loneliness"), and I guess that the TV commentators must be reveling in my solitude and deriving all sorts of phony philosophy from it, but I hope not. Far from feeling lonely or abandoned, I feel very much a part of what is taking place on the lunar surface. I know that I would be a liar or a fool if I said that I have the best of the three Apollo 11 seats, but I can say with truth and equanimity that I am perfectly satisfied with the one I have. This venture has been structured for three men, and I consider my third to be as necessary as either of the other two.

Because the lunar module was designed to fly in a vacuum, it didn't need the streamlining of an atmospheric craft.

I don't mean to deny a feeling of solitude. It is there, reinforced by the fact that radio contact with the earth abruptly cuts off at the instant I disappear behind the moon. I am alone now, truly alone, and absolutely isolated from any known life. I am it. If a count were taken, the score would be three billion plus two over on the other side of the moon, and one plus God only knows what on this side. I feel this powerfully—not as fear or loneliness—but as awareness, anticipation, satisfaction, confidence, almost exultation. I like the feeling. Outside my window I can see stars—and that is all. Where I know the moon to be, there is simply a black void; the moon's presence is defined solely by the absence of stars. To compare the sensation with something terrestrial, perhaps being alone in a skiff in the middle of the Pacific Ocean on a pitch black night would most nearly approximate my situation. In a skiff, one would see bright stars above and black sea below; I see the same stars, minus the twinkling, of course, and absolutely nothing below. In each case, time and distance are extremely important factors. In terms of distance, I am much more remote, but in terms of time, lunar orbit is much closer to civilized conversation than is the mid-Pacific. Although I may be nearly a quarter of a million miles away, I am cut off from human voices for only forty-eight minutes out of each two hours, while the man in the skiff—grazing the very surface of the planet—is not so privileged, or burdened. Of the two quantities, time and distance, time tends to be a much more personal one, so that I feel simultaneously closer to, and farther away from, Houston than I would if I were on some remote spot on earth which would deny me conversation with other humans for months on end.

My windows suddenly flash full of sunlight, as *Columbia* swings around into the dawn. The moon reappears quickly, dark gray and craggy, its surface lightening and smoothing gradually as the sun angle increases. My clock tells me that the earth is about to pop into view, and I prepare for it by positioning my parabolic antenna so that it points at the proper angle. Sure enough, here comes the earth on schedule, rising swiftly above the horizon, and shortly thereafter I can tell from one of my many gauges that the antenna has locked onto its signal and conversation should be possible.

(Their lunar excursion over, Armstrong and Aldrin prepare to blast off from the moon's surface to rendezvous with Collins.)

When the instant of liftoff does arrive, I am like a nervous bride. I have been flying for seventeen years, by myself and with others; I have skimmed the Greenland ice cap in December and the Mexican border in August; I have circled the earth forty-four times aboard Gemini 10. But I have never sweated out any flight like I am sweating out the LM now. My secret terror for the last six months has been leaving them on the moon and returning to earth alone; now I am within minutes of finding out the truth of the matter. If they fail to rise from the surface, or crash back into it, I am not going to commit suicide; I am coming home, forthwith, but I will be a marked man for life and I know it. Almost better not to have the option I enjoy. Hold it! Buzz is counting down: "9—8—7—6—5 . . . abort stage . . . engine arm ascent . . . proceed . . . beautiful . . . thirty-six feet per second up . . . " Off they go: their single engine seems to be doing its thing, the thing earthlings have been insisting it could do for half a dozen years, but it's scary nonetheless. One little hiccup and they are dead men. I hold my breath for the seven minutes it takes them to get into orbit. Their apolune is forty-seven miles and their perilune is ten miles. So far so good. Their lower orbit ensures a satisfactory catch-up rate, and they will be joining me in slightly less than three hours, if all goes well.

Goddamn, it looks good! I can look out through my docking reticle and see they are steady as a rock as they drive down the center line of that final approach path. I give them some numbers. "I have 0.7 mile and I got you at thirty-one feet per second." Buzz replies, "Yes—yes, we're in good shape, Mike; we're braking." Jesus, we really are going to carry this thing off! For the first time since I was assigned to this incredible flight six months ago, for the first time I feel that it is going to happen. Granted, we are a long way from home, but from here on, it should be all downhill. Bigger and bigger the LM gets in my window, until finally it nearly fills it completely. I haven't touched the controls. Neil is flying in formation with me, and doing it beautifully, with no relative motion between us. I guess he is about fifty feet away, which means the rendezvous is over. "I got the earth coming up . . . it's fantastic!" I shout at Neil and Buzz, and grab for my camera, to get all three actors (earth, moon, and *Eagle*) in the same picture. Too bad *Columbia* will show up only as a window frame, if at all. Within a few seconds Houston joins the conversation, with a tentative little call. "*Eagle* and *Columbia*, Houston standing by." They want to know what the hell is going on, but they don't want to interrupt us if we are in a crucial spot in our final maneuvering. Good heads! However, they needn't worry, and Neil lets them know it. "Roger, we're stationkeeping."

Neil has turned *Eagle* around now, so that its black spot (the drogue used in docking) is directly facing me. Control passes from *Eagle* to *Columbia* at this point, as per our training sessions. It is easier to fly the docking maneuver from the command module; although it can be done from the LM, it is awkward for Neil, because he would have to crane his neck to see out an overhead window, whereas I can look straight ahead in more conventional fashion. So I sight through my reticle and align my probe with *Eagle*'s drogue, just as I did five days ago when I pulled the LM loose from the Saturn . . . . I am not the slightest bit worried as I draw closer and closer. The alignment looks very good indeed at the instant of contact, which I feel as a barely perceptible little nudge.

As soon as we are engaged by the three little capture latches, I flip a switch which fires one of my nitrogen bottles to start the retraction cycle, to pull the two vehicles together. When I do, I get the surprise of my life! Instead of a docile little LM, suddenly I find myself attached to a wildly veering critter that seems to be trying to escape. Specifically, the LM is yawing around to my right, and we are misaligned by about 15 degrees now. I work with my right hand to swing *Columbia* around, but there is nothing I can do to stop the automatic retraction cycle, which takes some six or eight seconds. All I can hope for is no damage to the equipment, so that if this retraction fails, I can release the LM and try again. Things are moving swiftly now, as I wrestle with my right-hand controller. We are veering back toward center line now, and get there, and *bang*, the docking latches slam shut, and miraculously all is well again. Whew! . . . It's time to hustle on down into the tunnel and remove hatch, probe, and drogue, so Neil and Buzz can get through the tunnel . . . . The first one through is Buzz, with a big smile on his face. I grab his head, a hand on each temple, and am about to give him a smooch on the forehead, as a parent might greet an errant child; but then, embarrassed, I think better of it and grab his hand, and then Neil's.

We cavort about a little bit, all smiles and giggles over our success, and then it's back to work as usual, as Neil and Buzz prepare the LM for its final journey and I help them transfer equipment into *Columbia*.

Wilbur and Orville: A Biography of the Wright Brothers. *By Fred Howard. Alfred A. Knopf, 1987. 530 pp., b&w photos, $24.95 (hardbound).*

Fred Howard has produced a big, solid book on the lives and times of Wilbur and Orville Wright. Readers who are familiar with the voluminous literature on the subject will find few important surprises here. The tale of the two genius brothers who triumph over both nature and those who seek to take advantage of them has been told many times since John R. McMahon published the first biography of the Wrights in 1930. Still, it has seldom been told so fully, or so well.

The author skims through those aspects of the story with which he assumes we are most familiar, providing a conventional treatment of the invention of the airplane in the first third of his book. It is a useful review, but those seeking details on the Wright technology are advised to turn to Harry Combs' *Kill Devil Hill,* Howard Wolko's *The Wright Flyer: An Engineering Perspective,* or, best of all, *The Papers of Wilbur and Orville Wright,* which Fred Howard helped edit.

The present volume's greatest strength is the fascinating account it offers of the Wright brothers' struggle to market their invention and to reap a just reward during the years after 1905, the year they mastered powered flight. Howard gives us a marvelous sense of the time and place—the United States and Europe at the peak of Edwardian splendor. In addition, he serves up rich characterizations of the starring and supporting players, from scalawag rivals like Augustus M. Herring to the King of England.

Step by step, the author walks us through the maze of intrigue and negotiations that preceded the public unveiling of the Wright airplane in 1908. In the aftermath, the brothers found fame and fortune, and their work provided a starting point for everyone who came after them. And yet, success in business escaped them.

In Howard's telling, the Wrights were forced to wage bitter legal battles with Glenn Hammond Curtiss and others who sought to infringe on their patents and strip them of the honors they had received for their invention. The brothers won those battles, but the price of victory was high. Wilbur, his health undermined by stress, succumbed to typhoid in the spring of 1912. Orville fought on alone, feuding for 20 years with Smithsonian officials who claimed that the 1903 Wright machine was not the first airplane capable of flight.

Wilbur and Orville offers a satisfying portrait of the world through which the brothers moved. It deserves a place on the bookshelf of every aviation enthusiast. In spite of the author's best efforts, however, our most fundamental questions remain unanswered: Why did Wilbur and Orville succeed where so many others had failed? What manner of men were they, and what forces shaped them? Why does controversy continue to swirl around them? More than eight decades after the birth of powered flight, the two bicycle makers from Dayton continue to fascinate and intrigue us, while confounding and eluding those who seek to understand them.

—Tom D. Crouch supervises the Division of Engineering and Industry at the National Museum of American History. He has written a number of books on the early history of aeronautics, including A Dream of Wings: Americans and the Airplane, 1875–1905.

Wright State University

Left, Wright, left: Wilbur and Orville stayed one step ahead of their competitors.

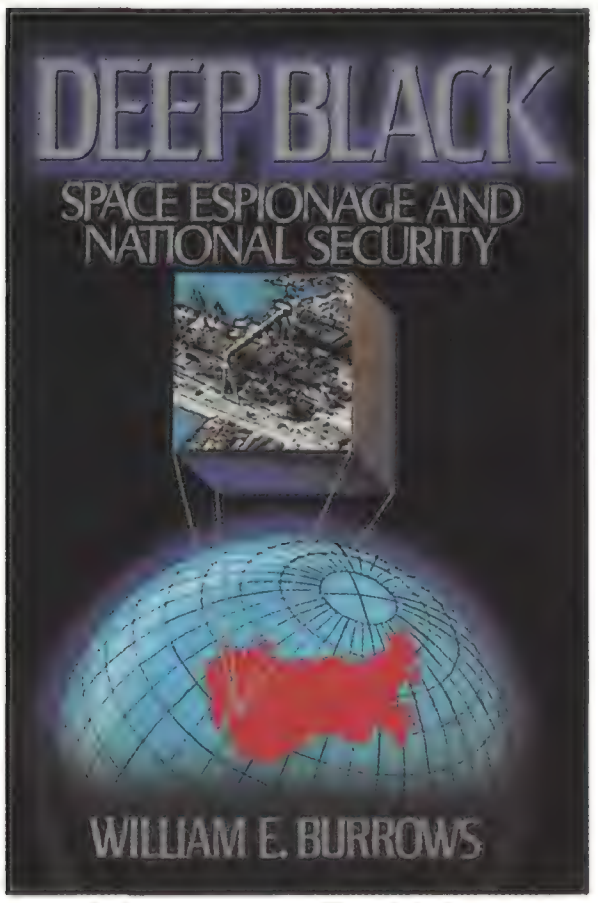
Deep Black: Space Espionage and National Security. *By William E. Burrows. Random House, 1986. 401 pp., b&w photographs, $19.95 (hardbound).*

On Jimmy Carter's second day as president, the acting director of the CIA came to the Map Room of the White House. There he spread out a number of black-and-white photographs, each about six inches square. The pictures had been taken the previous day by a KH-11 spy satellite. Carter had only recently been briefed on this new technology, which allowed U.S. intelligence to evaluate images of tanks moving in Poland or Soviets working on a test missile within minutes after these events occurred.

Carter studied the pictures, smiled, and asked the CIA man to send more samples to the White House for the first meeting of his National Security Council. A Ronald Reagan might have noted how the new satellites could help warn the nation of a surprise attack, or guide the waging of war. Carter declared that the new technology would be "of value in our arms control work."

Until recently, most Americans have not been aware of the degree to which their security depends on state-of-the-art satellites racing around the globe, and this ignorance has not been accidental. Since the United States and the Soviet Union began trying to monitor each other's territories from spy planes after the second world war, the two governments have

treated aerial reconnaissance as just another form of espionage, to be kept secret. Only in the 1970s, after each had gained the ability to watch the other's landmass from satellites, did they publicly acknowledge the vital role of space espionage in keeping peace; U.S.-Soviet arms control treaties specified enforcement by "national technical means of verification." The euphemistic nature of this language suggests the oblique manner in which both governments talk about



reconnaissance from space. Even now, the U.S. government does not concede that its National Reconnaissance Office exists.

There are few worlds more difficult to document than that of intelligence. Written records are, for the most part, simply not available. Delving into this subject calls for extraordinary abilities, and William E. Burrows, a journalist who now directs the Space and Environmental Reporting Program at New York University, is a researcher of the first rank. Combining a careful and skeptical reading of published sources and his own interviews with intelligence officials, scientists, technicians, scholars, and others, he provides the code names, figures, and other heretofore unavailable facts that make this book the standard reference on its subject. At the same time, the book is devoid of the carnival-barker tone of so many other books on current intelligence. He traces the antecedents of aerial observations from 18th century French balloons to the U-2s that roamed deep into the Soviet Union in the late 1950s, and he does a superb job of explaining the system by which political leaders today are able to gain information on sites around the world on little more than a moment's notice.

What interests Burrows most of all is the role space espionage serves in international relations. He shows how electronic collection systems reveal the adversary's military capabilities (or lack thereof), the possibility of surprise attack, and the degree of compliance with arms control treaties. He resents attempts to undermine arms control with the charge that space reconnaissance is not foolproof.

His conclusion: "To insist that we cannot see what we need to see, while seeing only what we want to see, is to condemn ourselves to live with the demons of our own creation forever. That is how big this is."

—Michael R. Beschloss is a Smithsonian historian and the author of Kennedy and Roosevelt *and* Mayday: Eisenhower, Khrushchev and the U-2 Affair.

Chennault: Giving Wings to the Tiger. *By Martha Byrd. University of Alabama Press, 1987. 480 pp., b&w photos, $25.95 (hardbound).*

Chennault. *By Jack Samson. Doubleday, 1987. 343 pp., b&w photos, $18.95 (hardbound).*

The Maverick War: Chennault and the Flying Tigers. *By Duane Schultz. St. Martin's Press, 1987. 327 pp., b&w photos, $18.95 (hardbound).*

The man who commanded a mercenary air force for Nationalist China was born in Commerce, Texas, on September 6, 1893.

Or was he? Commerce seems to be right, though there is no documentation of Claire Chennault's birth in Texas or anywhere else. The month and day are not much disputed . . . but the year! Martha Byrd weighs the evidence and concludes it was 1893, while Jack Samson takes the conventional view that the contentious airman was born in 1890. The conflict is revealing, not just of the difference between the two biographies, but also of the enigma that was Claire Chennault.

A retired U.S. Army Air Corps captain, he went to China in 1937 and became "the Colonel," directing the Chinese Air Force against encroaching Japan. By 1940 the CAF had been destroyed, and he returned to the United States to hire—with the secret approval of the White House—military pilots to fly for China. These irregulars became famous in the defense of Burma as the Flying Tigers, and after Congress formally declared war on Japan, Chennault was recalled from retirement, commissioned a brigadier general, and given command of the U.S. air effort in the China theater. Fired on the eve of victory—he opposed his superior officer, Lieutenant General Joseph Stilwell, almost as vigorously as he opposed the Japanese—Chennault founded a civil airline with links to Nationalist China and U.S. intelligence services. In so doing, he invented the sort of clandestine aerial warfare that would later become notorious in Southeast Asia and Central America.

Martha Byrd's biography is a work of scholarship, always to be preferred where there is a conflict. What she contributes to our knowledge of the man is astonishing. She recounts a yarn about Chennault's father's less-than-cordial relations with a horse trader, and even makes an intriguing educated guess that it was Chennault who set off the bloody battle for Shanghai in August 1937, hoping to shift the war to ground that was more favorable to the Chinese. Even the illustrations are remarkable, including a photograph (from a home movie) of Chennault flying a biplane over China. Yet she presents these wonderful findings in relentlessly sober prose. She will not deal in nicknames, nor will she tell us what her characters looked like or—in Hemingway's lovely phrase—how the weather was.

Those who like their history with a splash of bourbon will prefer Jack Samson's book. It moves swiftly, opening with the airman en route to the Far East in the spring of 1937. It tells us how the weather was, and in convincing detail, for the author served in the U.S. air arm that superseded the Flying Tigers, and he later worked for Chennault's cloak-and-dagger airline. He is less persuasive when he gives us insights that more properly belong in a novel: "His hands were shaking," Samson says of Chennault at his first air raid. "He inhaled and slowly blew the smoke from his lungs. So this was war."

Yet both biographies are welcome, if only as antidotes to what has gone before. For decades, Chennault was left to the mercy of popularizers, while the other side got the historians. (Barbara Tuchman, especially, gave Chennault a black eye in her important study *Stilwell and the American Experience in China.*) Chennault made important enemies—not only that quintessential infantryman Vinegar Joe Stilwell, but the army's commander of air forces, H.H. "Hap" Arnold, and its magisterial chief of staff, George C. Marshall. To align yourself with Chennault is necessarily to reassess these giants, a

process now begun by Byrd and Samson.

Less worthwhile is Duane Schultz's account of the Flying Tigers that made Chennault famous. In contrast to Byrd and Samson, Schultz relies almost entirely on other people's books. Worse, he repeats every fable as fact, choosing the most astounding figure and often improving on it—assuring us, for example, that Chennault spent a month spying in Japan before he reported to China in 1937. The usual version is one week. The truth, as Jack Samson abundantly chronicles, is two nights and a day.

A more serious lapse is that Schultz—40 years after Japanese records became available to historians—has the Flying Tigers shooting down Zeros by the score. The Mitsubishi Zero-Sen was a navy airplane. The air war over Burma was fought mostly by army pilots, who flew the similar but lightly armed Nakajima Hayabusas—Falcons—and those in extremely small numbers. In March 1942, the Japanese Fifth Air Division had 15 Hayabusas and 60 older fighters in Burma, as compared to the 450 aircraft Schultz hurls in relays against the defenders.

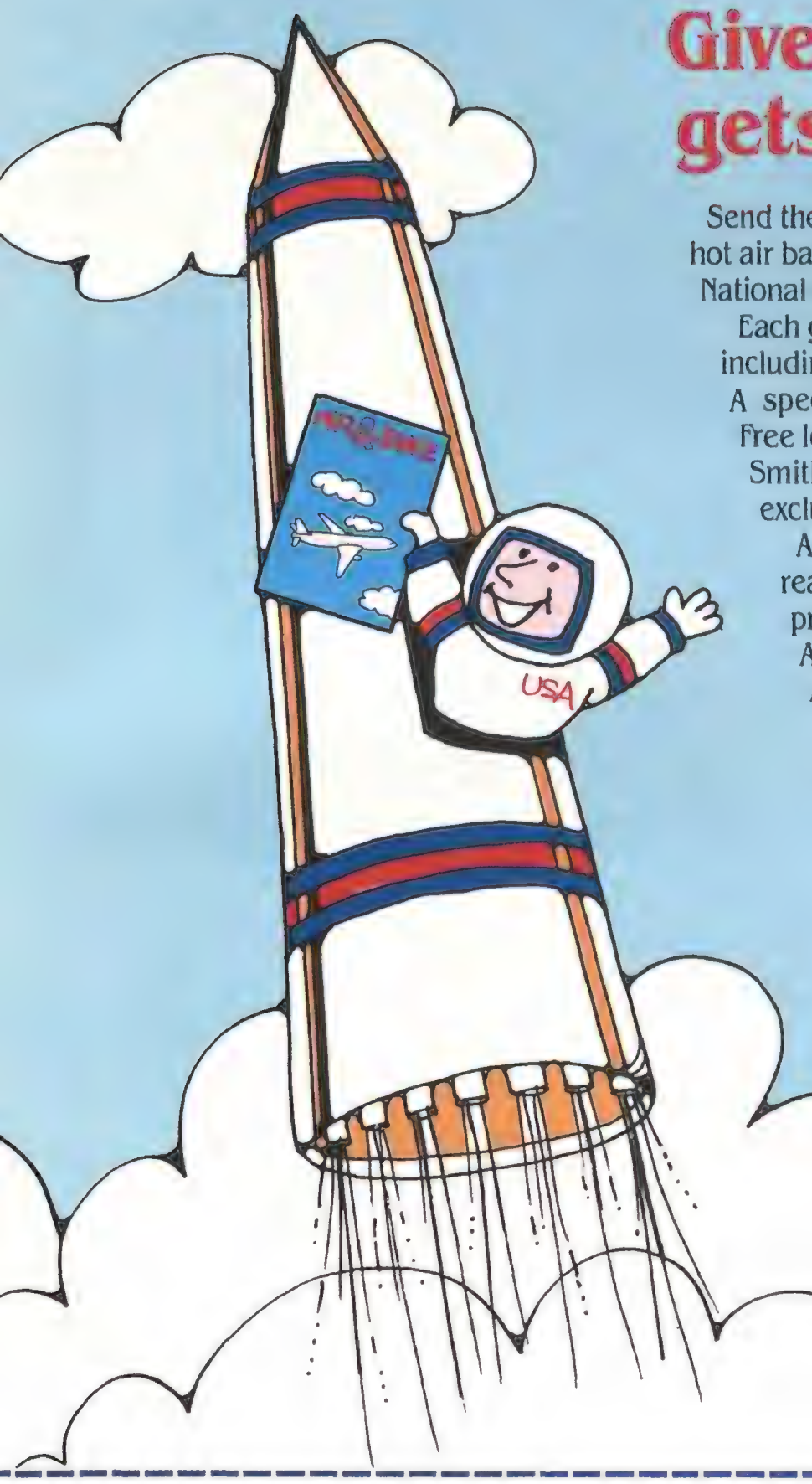
The myth of the invincible Flying Tigers helped comfort an America dismayed by its defeats in the opening months of the war in the Pacific. Yet the Tigers too were driven out of Burma, and only five pilots followed Chennault when his mercenary force was inducted into the U.S. Army in July 1942. This unpalatable outcome is variously blamed on Stilwell's stupidity, Chinese venality, British cowardice, those infinite Zeros, or a final collapse of morale among Chennault's pilots.

The truth is simpler. Fallible men fought well with inadequate equipment, on both sides. All honor to them and their commanders, such officers as Lieutenant Colonel Tateo Kato of the Japanese Army Air Force, and the remarkable Claire Chennault.

—Daniel Ford is writing a history of the Flying Tigers. His account of how the United States sold China 100 fighters—the shark-nosed P-40s flown by Chennault's mercenaries—will appear in an upcoming issue of Air & Space/Smithsonian.

The Rise of American Air Power: The Creation of Armageddon. ***By Michael S. Sherry. Yale University Press, 1987. 435 pp., b&w photos and illustrations, $29.95 (hardbound).***

Michael S. Sherry's *The Rise of American Air Power* is a convincing indictment of the excesses of American aerial bombardment



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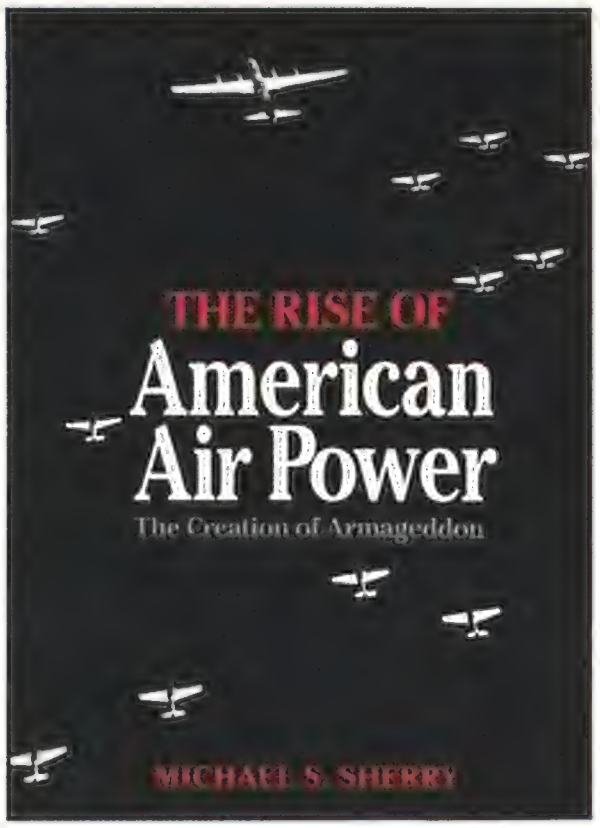
during World War II, sure to offend those World War II military and civilian leaders (and their defenders) responsible for planning and executing the strategic bombing campaigns in both the European and Pacific theaters. Antagonized readers, however, will have difficulty disputing Sherry's arguments because the author has researched his subject in admirable depth.

Sherry's book plumbs all the available sources—primary, secondary, fiction, even film—to produce a history of air power dealing more with ideas than events. The author, citing popular civilian and military writing before World War I and during the 1920s and 1930s, shows that "the warplane was created in the imagination before it was invented as a practical weapon" and that "practical developments were usually secondary to imagination in shaping strategic air war." One would have to search long for a better and more concise critique of interwar thought on strategic bombardment, as shaped by such men as J.F.C. Fuller, Basil H. Liddell Hart, Guilio Douhet, and Billy Mitchell.

Sherry masterfully weaves a complete fabric because he understands the subtleties and complexities of the times, and he exposes all the conceptual threads of aerial war. The political, technological, moral (or amoral), social, racial, and banal forces that produced destruction in Hamburg, Cologne, Dresden, Berlin, Tokyo, Hiroshima, and Nagasaki are all examined.

Why was strategic bombardment so attractive to U.S. politicians, soldiers, and, most importantly, the country at large? Because "it promised victory . . . by employing the bomber as an instrument of surgical precision rather than indiscriminate horror, laying its high explosives (not gas or incendiaries) on targets with pinpoint accuracy, incapacitating the enemy without slaughter." The wayward path of precision—in both World War II theaters—and the descent of the bomber from scalpel to bludgeon are described dispassionately, with only a pinch of preachiness.

Sherry shows that the theory of strategic precision bombardment had numerous unexamined flaws. The theory depended on finding targets of such significance that their loss would force surrender. But discerning such targets demanded a sophisticated and highly professional intelligence apparatus. Further, the adversary might have any or all of the following: stockpiles, alternative suppliers, substitutes, or rapid repair capabilities. Another crucial flaw involved bombing accuracy: pinpoint accuracy demanded



navigation skills that did not exist until well into the war, and equally deleterious, contemporary assumptions regarding the wind were not true. Few things in war are more capricious than objects dropped from airplanes.

In practice, strategic bombing did not even approximate its promise. That is not to say, however, that aerial bombardment failed to make a major—even, in some senses, decisive—contribution to the Allied victory. It is an important measure of Sherry's balance that he acknowledges the immense, although exceptionally expensive, contribution made by the U.S. Army Air Forces to the victory.

In addition to detailing the successes and failures of the air war, Sherry sounds a warning for the future throughout his book. Before World War II, many politicians and soldiers held a comforting idea about air power—aerial bombardment was so terrible to contemplate that states would be deterred from starting wars if their adversaries had an air force. It proved to be a terribly false hope. Sherry warns readers to beware of assertions that "visions" of aerial destruction "will shock the world into controlling or abolishing aerial weapons." He understands the people of the 1930s and their hopes for peace, and he understands contemporary yearnings too: "Just as one generation learned to accept bombing as the terror that could not happen, so too has this generation accepted the [nuclear] bomb itself," Sherry writes. "The parallel, hardly comforting, may be instructive."

—Alan L. Gropman is a principal analyst for the SYSCON Corporation and a frequent lecturer on aviation at the Smithsonian.

Ghosts: Vintage Aircraft of World War II. *Photographs by Phillip Makanna; foreword by Chuck Yeager. Thomasson-Grant/Ghosts, 1987. 120 pp., $38.00 (hardbound).*

Phillip Makanna's striking photographs of 1940s military aircraft are well displayed in this volume, and are complemented by excerpts from books by and about vintage-aircraft pilots.

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Cover. Charles H. Phillips is a freelance photographer who has worked for *Smithsonian* and Time-Life Books. He covered the White House and Capitol Hill between 1968 and 1972 for *Life* magazine.

The Dachang Douglas. Charles Barton is special correspondent on Chinese civil aviation for *The Journal of Commerce.* A former Navy pilot, he was commanding officer of the Airborne Early Warning Squadron One (VW-1), also known as "Typhoon Trackers."

Further reading: "Airport Development," Beverly LoPinto, *The China Business Review,* July-August 1986.

The Day the Rocket Died. Fred Reed is a frequent contributor to *Air & Space/Smithsonian.*

Further reading: *Vanguard: A History,* C. Green and M. Lomask, Smithsonian Institution Press, Washington, DC, 1971.

Putting Mars on the Map. Gary Graf is a freelance space technology writer and commercial photographer living in Denver.

Jim Richardson's first view of Mars was through a homemade telescope on the family farm in Kansas. He is known for his documentary photography of small towns.

Further reading: *The Surface of Mars,* Michael Carr, Yale University Press, New Haven, 1981.

Photographic Catalog of Selected Planetary Size Comparisons (NASA EP-86207), U.S. Government Printing Office, Washington, DC, 1985.

High Gs, High Risk. Jay Stuller, a San Francisco-based writer, is a frequent contributor to many national magazines. One short ride in an old, slow T-33 quickly ended his *Top Gun* fantasies.

Greg Harlin is no stranger to the effects of G forces. In his spare time, he has been known to double as an airplane for his toddler daughter, Hannah.

Further reading: "Living and Dying at Nine Gs," Ehud Yonay, *California Magazine,* April 1987.

Mr. G. Neil McAleer is a science writer whose most recent nonfiction book is *The Omni Space Almanac* (Pharos Books, New York, 1987).

Further reading: "Wooooosh!" Col. John P. Stapp, *Flying Safety,* January 1981.

Cake, Candles, Ice Cream, and Classifieds. Lorraine Norwood is a freelance writer from Hendersonville, North Carolina. She comes from a family of pilots who are absolutely mortified that one of their own prefers to stay on the ground.

Will and Deni McIntyre are a husband-and-wife freelance photography team living in Winston-Salem, North Carolina.

Further information: To subscribe, write to *Trade-A-Plane,* P.O. Box 929, Crossville, TN 38555.

The Boss. Tom Huntington is an associate editor at *Air & Space/Smithsonian.*

Further reading: *CV: Carrier Aviation,* Peter Garrison, Presidio Press, San Rafael, CA, 1980.

A Case of Identity. William Garvey, former editor of *Professional Pilot* magazine, labors at LGA, resides near HPN, and plans to escape to PPG.

Further reading: *Location Identifiers,* International Civil Aviation Organization, 1000 Sherbrooke West, Suite 628, Montreal, Quebec, H3A2R2, Canada.

Space Toys. Devera Pine is a New York-based freelance writer who specializes in health and science.

Further reading: *Science Fiction Toys and Models,* Stephen J. Sansweet, Starlog Press, New York, 1980.

For information on space memorabilia, write or visit Kansas Cosmosphere and Space Center, 1100 North Plum, Hutchinson, KS 67501, (316) 662-2305.

Toys courtesy of Tony Auth, Lloyd Ralston, Kenner Products, and Hasbro.

Mark Brender, Reporting from Space. Harry Jaffe is a Washington writer and contributing editor at *Regardie's.*

Further reading: *Commercial Newsgathering,* Office of Technology Assessment, Government Printing Office, Washington, DC, 1987.

What's in an Image? David Bartal is a freelance writer who reports regularly for *U.S. News & World Report.*

In the Company of Condors. Jack Lambie, an aerodynamicist and seasoned pilot, is a man of many feats. His achievements range from designing and flying replicas of Wright Brothers airplanes to winning $10,000 on the game show "Family Feud."

In Search of Miracles. Edwards Park is a columnist for *Smithsonian.* When flying, he always insists on a seat with a view.

Blithe Spirit. Brooke Hearn divides her time between teaching and writing.

"The Satellite Sky" Update/3

These regular updates to **"The Satellite Sky"** chart will enable readers to keep their charts up to date. Additions can be clipped and affixed to the chart at the appropriate altitude.

New launches

90 to 300 MILES

- Cosmos 1860 6-87 TT
- Cosmos 1865 7-87 TT
- Cosmos 1866 7-87 PL
- Cosmos 1870 7-87 TT
- Progress 31 8-87 TT

300 to 630 MILES

- Cosmos 1861 6-87 PL
- Cosmos 1862 7-87 PL
- Cosmos 1864 7-87 PL
- Cosmos 1867 7-87 TT
- Cosmos 1868 7-87 PL
- Cosmos 1869 7-87 PL
- DMSP 6-87 VAFB

630 to 1,250 MILES

- Cosmos 1852-59 6-87 PL

Additional satellites
300 to 630 MILES

- SME 10-81 VAFB
- Landsat 4 7-82 VAFB

Deletions

90 to 300 MILES

Cosmos 1847
down 7-22-87

Progress 30
down 7-19-87

Cosmos 1848
down 6-11-87

Soyuz TM-2
down 7-30-87

Glomar
down, date unknown

Launched but not in orbit

90 to 300 MILES

Cosmos 1863 USSR photo recon	7-4-87	down 7-18-87
Cosmos 1871 USSR unknown	8-1-87	down 8-10-87
PRC-20 China research	8-5-87	down 8-10-87

Inoperative but still in orbit

90 to 300 MILES

Cosmos 1788
Cosmos 1815

300 to 630 MILES

Cosmos 1602
Cosmos 1666
Cosmos 1674

Correction to first Update (June/July 1987)

Soyuz TM-2 (90 to 300 MILES) and Meteor 2-15 (300 to 630 MILES), printed on the poster, were inadvertently listed as new launches.

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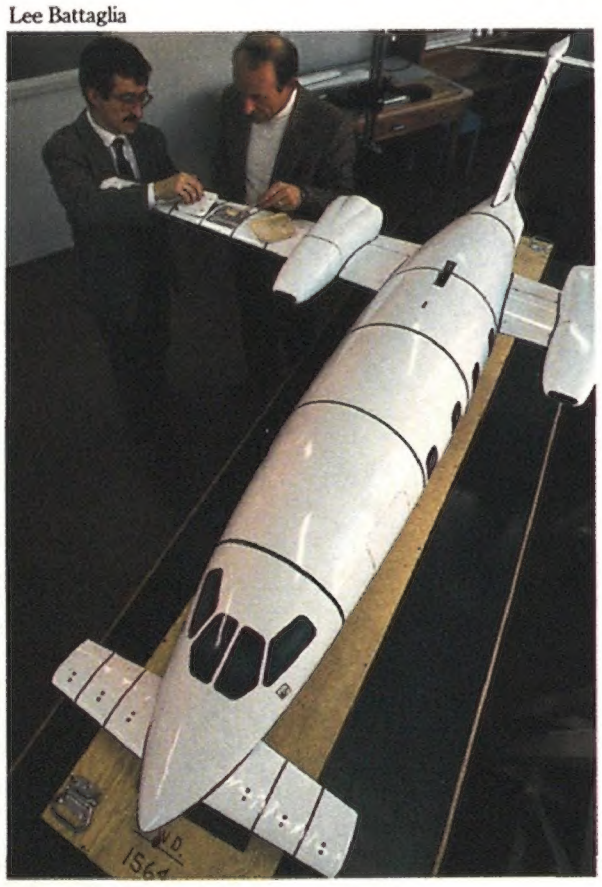
In the Wings . . .

Gucci, Pucci, P.180—The Italian aircraft manufacturer Rinaldo Piaggio is wrapping up the flight and wind-tunnel testing of its P.180 Avanti (a model used for wind-tunnel flutter tests is shown below). The twin-turboprop can carry as many as seven passengers quickly, quietly, and efficiently. The airplane's unusual configuration aims at low operating cost, but it sounds like the company's ads will be stressing quality, not cost. "We proposed to build an aircraft for J.R. Ewing," says chief engineer Alessandro Mazzoni. "Instead of market research, I watched 'Dallas.' I noticed that they drive expensive foreign cars, wear Cardin, Armani, and Ferré, so why not fly a Piaggio?"

Lee Battaglia



Betsy Who?—Chuck Yeager's supersonic Bell X-1 was powered by an innovative little number that, while weighing only 210 pounds, could crank out 6,000 pounds of thrust. Her name was Betsy.

Andrea Booher

Ski Wings—Dave Toland thinks he's invented the perfect cure for those alpine blues. His lightweight "wings" hook onto ski poles to create a billowing variation on the parachute theme. Now, with practice, a properly equipped skier can whoosh and schuss—and soar.

A Fitting Tribute—Larry Kuznets had just started teaching a course on space science at the University of California in Berkeley when the *Challenger* exploded. So instead of lectures, he gave his students a project: build a full-scale model of the front section of a space shuttle. The students learned about shuttle design, and a Berkeley science museum got a memorial to the *Challenger* crew.

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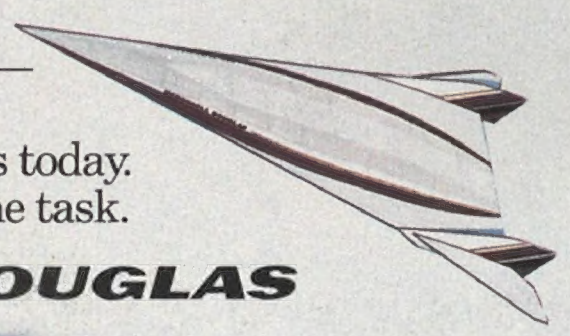

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